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Machine Tools used in Automobile Construction.

By E. C. AMOS, M.I.Mech.E.

THE motor car has come to stay, and in doing so has created an industry beneficial in its effects upon the manufacturers both of this and other countries. The disadvantages under which Great Britain laboured at the advent of the industry as compared with some of her Continental competitors, due to want of new and revised legislation in regard to vehicular traffic, no longer pertain. We have overtaken the ill effects of that shortsighted policy on the part of our legislature, and are now holding our own.

As a machine tool specialist of many years standing, and as an old motorist having a practical acquaintance, both as owner and driver, with cars of various types and kinds, the author may perhaps be permitted to refer to some of the leading points which go to make a good car. In so doing he hopes to increase the readers' interest in this series of articles.

In the early days, the industry was largely left in the hands either of cycle dealers, miscellaneous engineers, and the like, or was controlled by those who had been enterprising enough to secure the selling rights of some foreign car, but who, in most cases, were not engineers.

Indeed, it is not too much to say that our leading firms rather "sniffed" at the thing as a manufacturing proposition, and considered it beneath their dignity to consider the matter.

Some twelve years ago the author read a short paper on "Horseless Vehicles," as they were then termed, and well remembers the ridicule which his remarks elicited when he expressed the opinion that they would in the near future largely supplant horse-drawn vehicles.

The last year or two, as evidenced by the leading exhibitions, has seen a great change so far as our own manufacturers are concerned, and with the result that the machine tool industry has been very busy.

A number of our great engineering firms have now realised the possibilities of the business, although as yet our requirements, and especially for our public

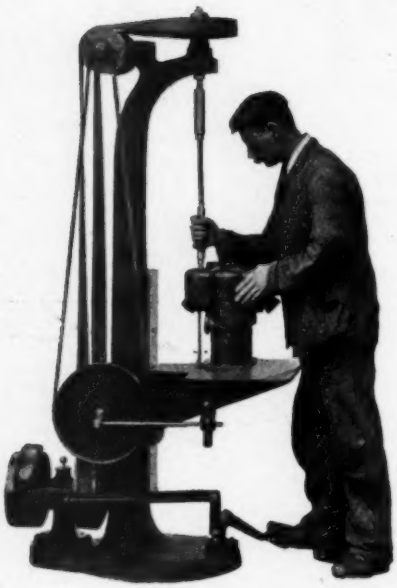


FIG. 1.—THE "HERBERT" VALVE GRINDING MACHINE.

vehicles, are chiefly drawn from abroad. Why is this? Many answers might be given, diverse in their nature, according to the point of view, and yet most of them containing some measure of truth.

As this is not an article upon the merits of British *v.* Continental design, it is not desirable to reply to the query already put, except so far as it concerns the question of the machinery used for the construction of cars.

It will not be denied that France, Italy and Germany have sunk an immense amount of capital in laying down special and expensive machinery for the manufacture of cars, and that such expenditure is proving very profitable. The same is also true of America, although we see very few American cars here, some of the best not yet having made their appearance on this side.

In order to manufacture a car which shall satisfy the public in respect to price, material, and workmanship, and which shall at the same time leave a reasonable profit to the builders, it is absolutely necessary to manufacture in large quantities and in a few types. The question of design has been left out, as already mentioned, as this is a delicate matter, and so far as these articles are concerned does not enter into the question. All we are concerned with are methods of manufacture, and we shall not discuss the product of the drawing office except on broad lines. The mistake made by so many of our own manufacturers and not a few Continental ones has been the attempt to supply a great variety of types and powers, cars having one, two, three, four and six cylinders (not to mention eight), and with powers ranging from five to fifty horse-power, all being made in the same works. With such a variety it is not difficult to understand that standardisation and interchangeability are impossible. If one were asked whether he preferred a well designed car badly constructed (that is, faulty material and workmanship) or a badly designed car made of the best material and with the best workmanship, it is probable that preference would be given to the latter. What the public asks for first and foremost is reliability; this cannot be obtained unless the materials used are suited for the work they have to perform, and the machining of the various parts and fitting together are of the best.

Now it is not possible to put in the best material and workmanship and at the same time sell at a low price unless up-to-date methods are adopted, and these must include the laying down of the most efficient machinery possible. It is the object of these articles to refer to a few of these machines. Fig. 1 shows one of the most recently invented machines for motor car manufacturers. This is the "Herbert" valve grinding machine, and has been specially designed for grinding the valves of motor cylinders, and the time required to finish a set of valves has been found to average less than one-third of the time required by hand. The illustration shows the machine very clearly; the

following short description may, however, prove interesting :—

The machine consists mainly of a vertical column, carrying a self-contained countershaft, which drives a vertical spindle by means of a belt carried over guide pulleys.

On the front of the column is a vertical slide, which carries a rising and falling table in which the cylinders are placed. The spindle has a telescopic sleeve, the lower end of which carries a flexible shaft provided with a wooden handle which is free upon it. The lower end of the shaft carries a movable screw driver, the end of which is shaped to suit the valves to be ground.

The table has an automatic intermittent lifting apparatus by means of a belt driving a crank disc on the side of the column, and provision is made so that the length of the connecting rod automatically accommodates itself to the varying adjustments in the height of the table to suit different designs of cylinders. To grind a valve the cylinder is placed upon, but not attached to, the table of the machine ; the valve is put into position and the automatic lifter is adjusted for height to suit the length of the valve stem. The workman then depresses the foot lever, which moves the belt on to the fast pulley and starts up the spindle. The screw driver at the end of the flexible shaft is then pressed down upon the valve by means of the handle, which, when grasped by the workman, does not rotate. The screw driver takes hold of the valve by means of a notch provided for the purpose, and the grinding proceeds, the revolution of the valve being in the same direction all the time, but the valve is periodically lifted up off its seat for a short interval of time without disturbing its rotation. As soon as the foot is removed from the lever the belt is automatically moved on to the loose pulley by means of a spring.

Fig. 2 shows a number of pieces, forming part of the engine and chassis of a car, and which have been machined in special tools, to which reference will be made in subsequent articles.

Fig. 3 illustrates a " Parkinson " automatic spur gear cutter capable of dealing with spur wheels from 2½ ins. up to 48 ins. diameter by 10 ins. on the face.

The general design and construction of the machine is such as to give great rigidity and large output.

The column carrying the horizontal spindle and division wheel is cast solid with the bed, and both are of strong section and suitably braced and ribbed to resist strain and vibration. The cutter slide or saddle is guided along its bed by a guide 5 ins. wide and 23 ins. long, and is adjustable for wear by a taper gib. This secures smoothness of working with the minimum of twist or " wind," a very important feature in a gear cutter. The division wheel is of strong well-balanced form, and is 32 ins. diameter.

The workspindle head is adjustable vertically on the column by vertical

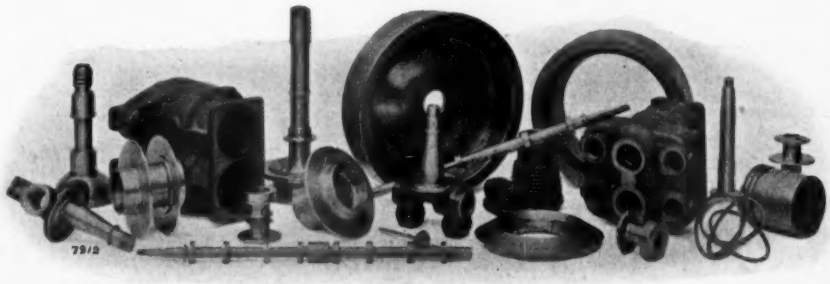


FIG. 2.—NUMBER OF PIECES FORMING PART OF ENGINE AND CHASSIS MACHINED BY SPECIAL TOOLS.

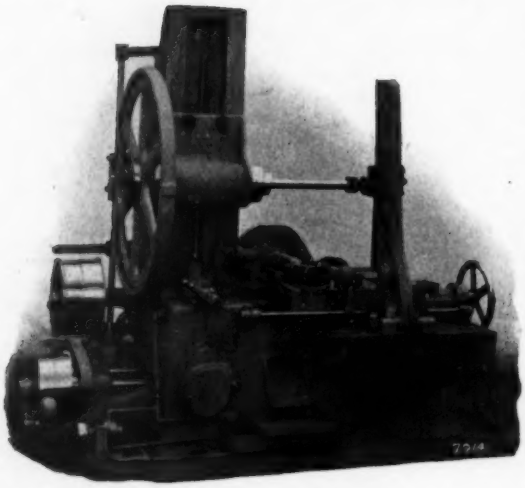


FIG. 3.—"PARKINSON" AUTOMATIC GEAR CUTTER.

screw, bevels, and a horizontal shaft situated at the lower part of the column. A thrust ball collar to take the weight when moving, and a dial for depth measurements giving readings of 1·1000 in., are provided.

The outer support for the work mandrel is arranged to take all diameters up to the capacity of the machine. It is hinged on a sole-plate, and can be swung clear, without unfixing, when changing work. The cutter spindle is hardened and ground, and has adjustment for wear. It is driven by worm and worm-wheel, has four changes of speed obtained by sliding gearing. The speeds range from twenty-five to seventy-five revolutions per minute.

The standard size is for cutters 1½ ins. diameter hole.

The cutter feeds have a range of twelve speeds from ·04 in. to ·18 in. per revolution of cutter. Change gears are provided for this purpose.

The division or indexing mechanism is friction driven, and is independent of the speed and feed of the cutter, and can only operate when the cutter is clear of the work. It has a graduated start and stop to avoid shock when completing the division.

A safety division stop is employed to prevent the cutter coming in contact with the blank, in the event of a false division being made through any accident to or failure of the division mechanism. Consecutive numbers up to 100 and from 100 to 400, prime numbers excepted, can be made with change wheels supplied. Teeth may be cut consecutively, or every second or fourth. By this arrangement, expansion caused by overheating during cutting is minimised. A pump, circulating pipes and reservoir can be fitted for use when cutting steel. The pump is driven from the machine and is supplied as an extra.

The machine, which is fully automatic, is provided with one work mandrel, 1¾ ins. diameter, unless otherwise ordered.

The machine is intended to be driven direct from the lineshaft where convenient, and fast and loose pulleys and striking gear are incorporated, rendering a countershaft with overhead fast and loose pulleys unnecessary. The machine is complete with tabulated charts for divisions and feeds.

(To be continued.)

Mr. Bilbrough on the Specific Heat of Steam.

By ROBERT H. SMITH.

It is to be feared that Mr. Sydney Bilbrough's investigation of the Specific Heat of Steam* may not receive the attention it possibly deserves on account of his often ambiguous style of describing his experiments and his theory, and also on account of his method of experimentation. For example, he uses Cent. and Fahr. temperatures together at random, and enters both such readings even in the same table without conversion, so that to check his arithmetic involves some labour. He uses the same thermometer for high and low temperatures by the device of tipping a random quantity of the mercury out of the bulb into the top of the stem, so that the reader is every here and there met by the startling statement that water boiled in his experiments at atmospheric pressure of 4·59° C. or 27·6° F. or some such figure; or that steam at high pressure and superheated shows a temperature of say 57·3° F. Although specific heat under pressure maintained constant is his main theme, in some parts of his paper he applies the term "specific heat," unqualified, to changes of condition in which the pressure changes, and, moreover, proceeds as if this were the same as specific heat under constant pressure. In describing changes in which pressure varies while the steam remains all the time superheated, he speaks of "the heat absorbed by the saturated steam in raising its temperature" balancing the "heat given up by the superheated steam in having its superheat reduced," although actually no saturated steam is present to take any part in the action referred to, while the superheated steam that is alone present does not have its temperature reduced, but raised; and this description is of the essence of his argument.

If, therefore, his investigation falls unconvincing upon the ears of the scientific world, he can not have much just cause for complaint.

Nevertheless, the kernel of it appears to be a new and useful method of investigating this problem, and moreover an easy one. It may, consequently, be desirable to try to extract the useful part of this kernel and to separate what there may be of husk.

The reviewer has tested Mr. Bilbrough's arithmetic in various places and has found no errors worth mentioning.

As steam departs from the saturated condition more and more towards the gaseous condition its specific heat under any specified restriction, such as that of constant pressure, changes. This has been known for some time past. In making his arithmetic deductions from his experimental measurements, Mr. Bilbrough *implicitly* assumes that this law of variation is identical at different pressures: whereas his own experiments contradict this assumption. It might be legitimate to neglect the change in the curve of variation throughout a small range of pressure; but he applies the assumption of identity to very large ranges of pressure. In so far as this affects his results, they certainly require revision.

He uses the "Peabody" throttling calorimeter to reduce steam generated under steady conditions to various pressures, and assumes that in the expansion through the instrument each pound of steam retains unchanged the same "total heat." This is the ordinary assumption made in using throttling calorimeters for any purpose, and in the

* See THE ENGINEERING REVIEW, pages 104—124.

meantime we assume it to be correct. He assumes the total heat H of dry saturated steam to increase exactly in proportion to its temperature t, and this again is generally admitted to be accurate.

Now in Tables I. to IV. Mr. Bilbrough gives measured results showing that, while the boiler pressure is maintained unaltered, the temperature past the throttle remains unchanged even though the pressure is varied very largely. He shows this result both for small changes of pressure and also for such extreme ranges as from 0 to 100 and from 100 to 150 lbs. per sq. in. He causes these changes of pressure quickly by more or less closing an outlet valve from the low pressure chamber into the atmosphere. He keeps his heating lamps applied to his boiler and superheater steady during this time, and, because of the shortness of the interval of time and the steadiness of the boiler gauge pressure, he assumes that the condition of the steam passing from the superheater remains unaltered. It must be said that the evidence for this is by no means complete or convincing. The partial closure of the valve to bring up the low pressure to 150 when the boiler pressure is at 175, or to 100 when the boiler gauge stands at 113, quite certainly diminishes the quantity of the steam flow, and this would probably, if not certainly, increase the superheating effected by the coil. Why does the experimenter not measure this superheat, so as to determine the effect of diminished flow? The probable effect is quite sufficient to alter the justifiable conclusions to be drawn. Apart from this minor objection, the inference that can be drawn is this: Since, outside certain limits of superheat, each isothermal is also a curve of equal total heat, the heat supply necessary to pass isobarically between any given pair of isothermals is the same at widely different pressures. That means that the isobaric specific heat is independent of the pressure. It does not follow that it is independent of temperature.

The above is what Mr. Bilbrough finds outside certain limits which he has determined at two points

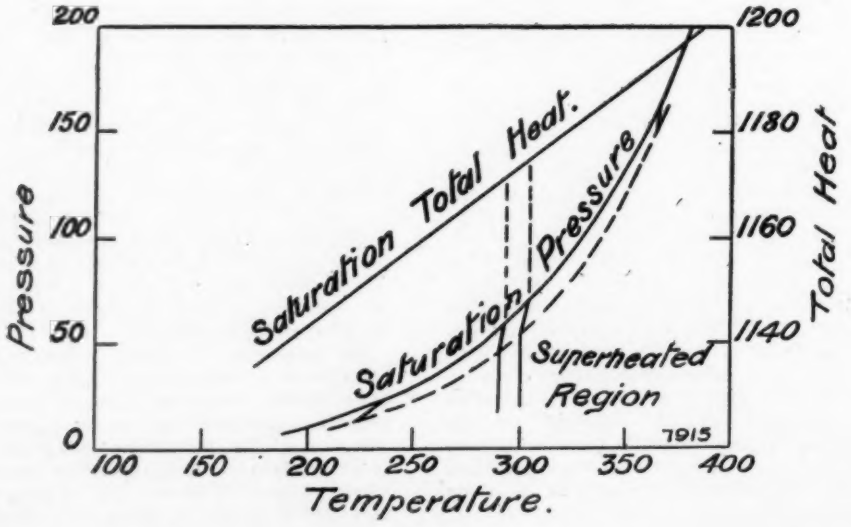


FIG. I.

only, namely, at atmospheric and at 150 lbs. per sq. in. pressure. In Fig. 1 of this critique a dotted curve shows these limits, while the full curve refers to dry saturated steam. To pass from the saturated condition into this region the steam must be led across the strip of diagram between the two curves, and in this strip the expansion curve of constant total heat gives the fall of pressure accompanied by a fall of temperature. It is to be observed, however, that the Tables V. to X. give invariably a very small fall of temperature even for very large pressure falls. The strip in Fig. 1 between full and dotted curves is a very narrow one, especially at its upper end: its width is slightly exaggerated in the drawing in order to make it plain on so small a scale. In this Fig. 1 two vertical lines at 290° and 300° have been drawn in the superheated region and indicate two such expansions of constant total heat. They are continued upwards by slightly sloping lines between the dotted and full curves; these short sloping lengths being the beginnings from saturation of the same constant-total-heat expansions. Now if these short sloping lines showed the same temperature-difference between their upper ends as between their lower ends, then the isobaric specific heat in the superheated region beyond the dotted curve would be independent of temperature as well as of pressure, and would equal ·305 at all points of this region. This is to be recognised by considering the vertical dotted lines running from the upper ends of the short sloping lines up to the straight-line diagram of total heat of saturated steam. The temperature gradient of this straight line is ·305.

According to Mr. Bilbrough, the horizontal distance between full and dotted curve is 16° F. at atmospheric and $3\frac{1}{2}$° F. at 150 lbs. pressure. The increase of temperature along the short sloping line between the two curves is, according to him, $16\frac{1}{2}$° F. at atmospheric and $1\frac{1}{2}$° F. at 150 lbs. pressure. It is this latter rise that he calls Q in his paper. At these limits thick short

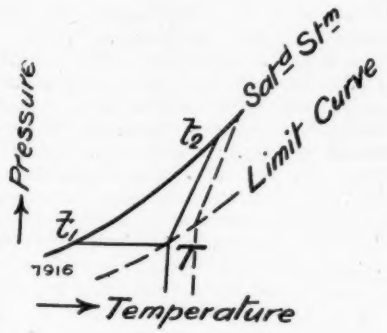


FIG. 2.

lines have been plotted in Fig. 1. His $1\frac{1}{2}$° difference is the mean of five results varying between 1·1 and 2·0. Taking his $16\frac{1}{2}$° and $1\frac{1}{2}$° as roughly correct, they evidently disprove the accuracy of his idea (of which his proof is illogical) that ·305 is the constant specific heat beyond the dotted curve; because they show a temperature spread of $16\frac{1}{2} - 1\frac{1}{2} = 15$° of the short oblique lines from their upper to their lower ends over a range of, roughly, 150° F. That is, the constant-total-heat lines beyond the dotted curve are more openly spaced *on the average* by $\frac{15}{150}$, or 10 per cent., than they are where they meet the saturation curve. So that the proper conclusion would be, not that the isobaric specific heat is constantly ·305 outside the dotted limit, but that its very rough

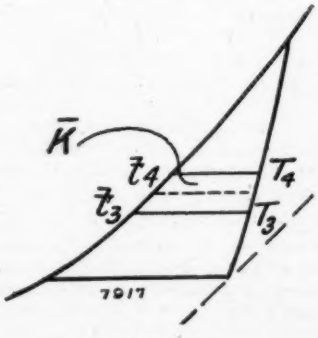


FIG. 3.

average throughout this space is 10 per cent. less than ·305, or, say, ·27.

Mr. Bilbrough names by the letter Y the heat conduction needed to pass isobarically between the two curves, and calculates it by the method illustrated in Fig. 2. Here t_1 and t_2 are points on the saturation curve, and T is a point on the dotted limit curve at the same pressure as t_1, while t_2 and T are on the same constant-total-heat curve. Between t_1 and t_2 the difference of total heat is $\cdot 305\ (t_2 - t_1)$, and the same difference exists between t_1 and T. Therefore the *average* isobaric specific heat between t_1 and T is $\cdot 305\ \frac{t_2 - t_1}{T - t_1}$. The difficulty is in determining with fair exactitude the temperatures t_2 and T at the ends of the sloping line corresponding to t_1. His $Y = \cdot 305\ (t_2 - t_1)$.

If now he repeated this experiment at a temperature of saturation t_1^1 a little higher than t_1 and found corresponding temperatures t_2^1 of saturation and T^1 at the dotted limit curve; then Fig. 2 shows clearly enough that at all pressures below that of saturation temperature t_1, and at the mean of the temperatures T and T^1 the isobaric specific heat in the superheated region is $\cdot 305\ \frac{t_2^1 - t_2}{T^1 - T}$. Mr. Bilbrough does not employ this method—indeed he assumes, without logical proof and contrary to his own results, that this specific heat is uniformly ·305 at all temperatures.

In Fig. 3 the points T_3 and T_4 are assumed to be on the same constant-total-heat curve at positions between saturation and the dotted curve. Mr. Bilbrough's experiments give the saturation temperatures t_3 and t_4 from observations of the pressures and, at the same time, T_3 and T_4. He applies a mean value of the specific heat midway between these pressures, averaged from saturation to curve $T_3\ T_4$. Calling this mean of an average $\overline{K}$—he omits to point out that it is a doubly averaged value—the difference of total heats at T_4 and T_3 is

$$\cdot 305\ (t_4 - t_3) + \overline{K}\ (T_4 - t_4 - T_3 + t_3),$$

and, as this is zero, therefore

$$\overline{K} = \cdot 305\ \frac{t_4 - t_3}{t_4 - t_3 - (T_4 - T_3)}.$$

In this way he endeavours to investigate the variation of specific heat within the strip between saturation and dotted curve. He neglects the effect of variation of $\overline{K}$ between t_3 and t_4; and, when this range is small, this neglect is justifiable. If $\overline{K}^1$ be the rate of variation with t_1 the correction which should be applied as an addition to the numerator of the above value of $\overline{K}_1$ is

$$\overline{K}^1\ (t_4 - t_3)\ \left\{ \frac{T_4 + T_3}{2} - \frac{t_4 + t_3}{2} \right\}.$$

By this means he finds specific heats a little beyond saturation much higher than 1 and, indeed, running up to 10. The value 1 means a specific heat equal to that of water; and it is difficult to believe that water vapour, however near saturation point, has a higher specific heat than water itself, and still more difficult to believe that it runs to so enormous an excess as 10. The experimentally measured differences of temperature are very small and the means relied upon by Mr. Bilbrough to find them, namely, from readings of gauge pressures and reference to tables of steam "properties," are too rough to induce us to give credence to so improbable a set of figures.

It must be remembered that the determination of the exact point at which all of a mass of water is evaporated—and the measurement of the latent heat evidently depends upon this—is one of extreme difficulty; and if it be found that there is a large absorption of heat through a minute range beyond the Regnault-reputed saturation point, it is much easier to believe that the evaporation was not quite complete at this point than to believe in an extravagantly large vapour specific heat. Regnault's straight line law for the total heat is suspiciously simple. A better way to state it is that a good physicist like Regnault would decline to make himself responsible for any minute refinements in the mathematical expression of

a quantity so exceedingly difficult to measure exactly, especially when he found the simplest possible mathematical expression very nearly represented all his experimental results.

The general objections to the method of the throttling calorimeter are two. The first is that it assumes that all the kinetic energy of outflow through the throttle is re-converted into heat in the steam, whereas it is a patent fact that all of it is not so converted. The second is that, granting the approximate accuracy of this first assumption, the real quantity that remains constant is the internal heat energy, which is a very different thing from the so-called "total heat." A third non-fundamental objection is that, as the instrument is usually arranged, the high-speed outflow of steam impinges directly upon the thermometer, while everyone who has tried it knows that the impact of a high-speed stream of any fluid heats the solid impinged upon to quite a material extent, but to an extent impossible to calculate.

Recent Experience in the Bacterial Treatment of Sewage.

By W. H. MAXWELL, A.M.Inst.C.E.

(*Continued from Page 275, Vol. 15.*)

Sheffield.—The sewage of Sheffield, like that of Manchester, has been hitherto dealt with by a system of lime precipitation followed by continuous filtration through coke, and, although these works were considered the best under the circumstances at the time of their design, the Sheffield Corporation have since found it necessary to adopt other means of coping with this problem. As is well known, a common feature of the lime process is the quantity of sludge resulting and the costly business of disposing of such large quantities of this material. The effluent, too, is liable to subsequent putrefaction. Before deciding upon the present scheme various alternatives were naturally inquired into. One suggestion was the establishment of a sewage farm in the Worksop or Doncaster districts, and another, the construction of a culvert from Sheffield to the East Coast, discharging into the sea. This latter proposal would have involved about 66·5 miles of culvert, and was estimated to cost about £1,300,000. Some less costly proposal, closer at home, was therefore sought.

Experimental work in the bacteriological putrefaction of sewage was started in the year 1897, and larger experimental beds were put down in 1899, consisting of three first contact and three second contact beds. The area occupied by the beds was about 9,500 sq. yds., and they were capable of dealing with the sewage from a population of about 30,000 persons. Gas coke of 3 in. to 5 in. gauge was used in the first contact, and fine coke breeze in the second contact beds. The depth of the first contact was 5 ft., and the second 3 ft. 4 in. The beds were worked at three fillings per day, and the preliminary treatment consisted only of rough screening and catch pits to remove the grosser solids, as in the case of the old lime process.

These experimental contact beds proved very satisfactory, and gave effluents well below the standards of purity usually required by river boards. As a typical example of the purification effected on the raw sewage, the analyses show a reduction in oxygen absorbed in four hours from 4·62 grains per gallon to ·26, free and saline ammonia from 2·3 to ·07, albumenoid ammonia from ·78 to ·018. The chlorine in the raw sewage and in the effluent being 7·6. The objects of the experimental work were

to obtain a practical test of the suitability of the bacterial process to deal with Sheffield sewage, to ascertain any weakness in the process, in order that they may be remedied in the complete scheme, should such be carried out. The beds were made with earthen sides and filled with coke. Although coke yielded a good effluent it was found, as has also been similarly experienced in other places, after a time to disintegrate with the action of the sewage. The importance of intercepting the road detritus before the sewage reached the beds was also apparent during the course of the experiments, in order to avoid their silting up.

After a sufficient period of experimental work, the principle of the scheme finally adopted provides for the settlement of the raw sewage in large tanks, followed by treatment of the effluent in bacteriological filters through furnace clinker. The capacity of the new works will be about 12 million gallons per day, equal to thirty gallons per head of the population, and is estimated to cost a sum of about £322,900 for works and land.

The scheme includes sixteen brick settling tanks of about one million gallons capacity each, and of a depth of 10 ft. 3 in. at the inlet end, and 7 ft. 3 in. at the outlet. The tanks will be provided with submerged walls, scum boards, &c., to assist deposit and retain the solid matters. There are sixty contact beds of about half an acre each, and of 4 ft. depth, filled with screened furnace clinkers. The walls and floors of the bed are of concrete, and the filtering area of each bed will be about 150 ft. by 150 ft. From the settling tanks a large main feed-conduit delivers the sewage to branch distributing conduits running between each pair of beds, and from which the sewage feeds to a distributing well placed in the centre of the bed. The clear effluent conduit is placed below the sewage carrier. From the distributing well the sewage flows over the surface of the beds in channels cut in the surface of the clinker, as in the case of the Manchester works. The supply of sewage to each bed is controlled by hand valves. The under drainage of the beds is suggested to consist of open-jointed earthenware pipes, bedded half their depth in the concrete floors, and communicating finally with the large effluent conduits above mentioned. In addition to the contact beds proper, the scheme also includes sixteen storm-water beds, of one acre in area each, and of 3 ft. depth of filling material. The walls of these beds are of concrete, but the floors will be earthen, with open-jointed earthenware pipes half bedded therein, for purposes of under-drainage. These beds are so arranged that they can be kept in constant use as contact beds for dealing with part of the dry weather sewage, or used as continuous filters in time of storm. By this means the storm-beds are kept in the best condition for dealing with the storm flows, and at the same time the capacity of the works is much increased by bringing them into use during ordinary dry weather flow.

Leeds.—The sewage of the city of Leeds, in common with that of many other large towns, has been dealt with upon the lime precipitation process. The present works are situated at Knostrop, and were completed in the year 1874. Although the length of sewers has since been considerably increased, these works remained without extension till 1897, when additional precipitation tanks were put down. The history of chemical precipitation here has been much the same as in other places where it has been in use. Two main difficulties, the character of the effluent and the large quantities of sewage, render the process at once unsatisfactory and costly.

> "Even if by the acquisition of land, and the provision of an adequate sludge-pressing plant, it became possible to remove the pressure of the sludge difficulty, it is necessary to point out that a process of precipitation, useful so far as it goes, is quite insufficient for sewage purification. The effluent, though it should be fairly clear and free from smell as it flows from the precipitation tanks, contains much organic impurity in solution, and is liable to decomposition and putrefaction."*

It is not surprising, therefore, that during recent years pressure has been put upon the corporation from the West Riding River Boards to improve the treatment at Knostrop, and to devise some more satisfactory mode of treatment. The whole question, however, was one of considerable difficulty, and occupied the attention of the Leeds authorities for some years. Various proposals were considered, until 1896, the attention of the responsible committee was attracted to the successful experimental work in the biological purification of sewage then being carried on at the Barking (London) Sewage Outfall Works, and at Sutton (Surrey). These works vere visited by the Leeds Committee, who, after due consideration, determined, in the year 1897, to put down experimental bacteria beds and thoroughly test the process for themselves, in order to ascertain to what extent the

* Report on "Sewage Disposal" (City of Leeds). July, 1900.

sewage of Leeds could be bacteriologically dealt with in a more satisfactory manner than by methods then in use. One very important point to determine, which was at the time a matter of considerable uncertainty—was the suitability of the bacterial process for dealing with the trade effluents, such as those from tanneries, the iron liquor from chemical works, and others peculiar to Leeds. Exerimental work on a practical scale has been carried on for some years with crude sewage upon bacteria beds, with effluent from lime precipitation, screened sewage, grit settled sewage, and septic tank effluent, and much valuable information has been gained, corroborating, in the main, the general results arrived at by other experiments. An admirable record of the work thus done to July, 1900, is presented in an interim "Report on Sewage Disposal" (City of Leeds), by the chairman, city engineer, and chemist to the committee issued at that date. Generally it is concluded, *inter alia*,

"That all the experiments in biological treatment showed the remarkable purifying effects of bacterial oxidation, and that it was more rapid in dealing with dissolved impurities than with solids in suspension, many of which are but slowly reduced. Double-contact beds gave good results with crude sewage, and excellent results with practically settled sewage or with septic effluent. Single contact beds are insufficient for dealing with crude sewage, but give fair results with settled sewage or with septic effluent . . . The continuous filtration of sewage or septic effluent on fine beds, although giving very good early results, would appear to be impracticable on account of the rapid choking of the beds. On the other hand, continuous filtration over very coarse material of septic effluent, and even of sewage has given interesting and remarkable results, if the solids in suspension, which come out in the effluent, are settled after filtration. These solids are non-putrescible, can be readily settled, and the drying does not give rise to evil odours. It would seem that the coming through of these solids, which for the most part are not further reducible, and largely mineral, ensures the performance of the coarse continuous beds . . . Neither the continuous, nor the intermittent systems of filtration give rise to any evil odours. Both give excellent results on chemical analysis, and effluents which improve and do not deteriorate on keeping. From the bacteriological point of view, however, all the filtrates contain a greatly larger number of bacteria than the standard of numbers allowed for drinking waters. This objection is not very material, as it is quite impracticable, in the treatment of sewage, to require transformation into a liquid of potable quality."

As the practical outcome of several years' experimental work and deliberation on the subject, a new project for the bacterial purification of the sewage of Leeds has been formulated. The leading features of this scheme provide, at Knostrop, for new screen and grit tanks to keep back mineral matter and the grosser solids, pumping plant to lift the first 2½ volumes from the sewer level to a chamber at a level of 85 ft., whence the flow would be by three 47 in. steel pipes to Gateforth, to be there treated; pumping plant to lift the second 2½ volumes of storm waters to the level of the existing tanks at Knostrop. At Gateforth the treatment will be first through settling tanks, then upon percolating beds, and finally, if necessary, through tanks or other means for the removal of oxidised suspended matters in the effluent from the percolating beds.

The first instalment of the scheme is calculated to deal with 80 million gallons of sewage, and is estimated to cost £1,000,000, including 15 per cent. for contingencies. The annual expenses, including 4½ per cent. for interest and sinking fund on capital cost, is estimated at £60,000, which is equivalent to about 7½*d.* in the £ on the present rateable value of Leeds.

Birmingham.—The works of the Birmingham Tame and Rea District Drainage Board situated at Saltley and Tyburn are among the most interesting in this country, and deal with the sewage of about 811,000 persons, amounting to some 25 million gallons daily normal dry weather flow. The total acreage of land owned by the board is 2,830 acres, and the works extend some six miles down the valley of the Tame. Thirty-three acres of land are used for the disposal of sludge, 950 acres for intermittent downward filtration beds, and 851 acres for broad irrigation. There are also 764 acres which are not being irrigated, and about 229 acres in roads, buildings, rivers, tanks, &c. The nature of the land is very variable, and includes stiff clay land, marl, gravelly material, gravel, a little sand, and a good deal of peaty land.

Formerly lime precipitation was in use, but this has now been entirely abandoned, and septic tanks holding about 7¼ million gallons, or about eight hours' flow, have been substituted for the preliminary preparation of the sewage. After this treatment the sewage of a population of 460 persons is dealt with per acre of land, or about 15,000 gallons, and a purification of about 90 per cent. on the crude sewage is obtained.

The growth of population within the district served by the board's works is such that it would be necessary, in order to keep pace with the increase of sewage, to acquire and lay out more than an acre of land per week to deal with the sewage on these lines, and it is therefore proposed to meet future needs by constructing five acres of percolating beds. The depth of these beds is

proposed to be 5 ft., and the method of distributing the sewage will be somewhat on the lines of that adopted at Salford. "Dortmund" tanks are proposed for arresting the humus in the septic sewage, and the supernatant water will be dealt with on three acres of primary beds and then finished upon two acres of secondary beds placed at a lower level.

Two continuous percolating beds of 120 ft. diameter have been in use about three years; one bed is supplied with sewage by a three-armed Adams' distributor, and the other by a Scott-Moncrief travelling rotary distributor. This apparatus is actuated by an oil engine, and consists of a trough arm carried on a fixed circular rail round the outside edge of the bed.

The annual cost of the sewage purification, including interest on capital outlay, and after crediting the farm account, is about 1s. 9*d*. per head of the population, which represents a rate of 5*d*. in the £.

From a recent report to the board it appears that the average purification of the effluent discharged into the stream for the past year has not been less than 92·3 per cent., judged by the oxygen absorbed standard, and 89·9 per cent. on the albuminoid ammonia basis. It is expected that the five acres of beds will be completed next year, and, in this connection, the engineer to the board has reported in the following terms:

"I cannot impress upon the committee too strongly the desirability of substituting bacteria beds for the intermittent filters which now occupy so large a proportion of the irrigation lands, and as one acre of bacteria beds is equal to 70 acres of lands (average quality), it is obvious that 15 acres of bacteria beds would be capable of dealing with the sewage for which at present 1,000 acres of intermittent filtration beds are required. Such an improvement would be incalculable from a sanitary point of view. It would set free a great area for growing grass or roots, and it would still further improve the effluent discharged into the river, as our chemist reports to me that he invariably obtains better effluents from the bacteria beds than he does from the land."

Recapitulation and Concluding Remarks on the Present Position of the Sewage Disposal Problem.—The first Sewage Commission was appointed in the year 1857, and after an inquiry extending over eight years, the Commissioners reported that "the right way to dispose of town sewage is to apply it continuously to land, and it is only by such application that the pollution of rivers can be avoided." Since that date the question has frequently been re-investigated by both Sewage and River Pollution Commissions, by numerous public authorities, as well as by a host of the most competent scientific workers. Yet there is, probably, no subject upon which the accepted practice of the moment has undergone such a constant radical change. Those who have had the opportunity of following the history of the various phases of this question, of noting the birth and brief existence of the many processes of treatment which have from time to time been introduced, will perhaps most fully appreciate the difficulties of the problem to be solved, and at the same time be the most ready to look for further developments in the methods now to the forefront.

During the past decade there is no doubt that a vast amount of original research work in the true principles underlying the purification of sewage has been accomplished far beyond anything previously achieved. The possibilities of bacterial treatment have been carefully investigated upon a practical scale in almost all parts of this country, as well as at numerous places abroad, and with sewages of widely varying composition. Yet, notwithstanding the large measure of success which has invariably attended the proper application of the system, few, it is imagined, will be bold enough to say that the last word in sewage purification has even now been said, or to venture the opinion that all the many problems in the practical application of modern methods have been "solved." But the more one investigates the subject, it *does* certainly seem that purification by bacterial agency is Nature's own way of dealing with a very troublesome question, and, from experience already gained, one is irresistibly led to the conclusion that the true and final field of inquiry has at last been entered upon in respect of present developments along biological lines.

As already intimated, near half a century ago the Royal Commissioners of that time, after eight years deliberation, ultimately decided in favour of the treatment (bacterial) of sewage on land in the definite words of their report quoted above. Bacteriological research, however, was not then sufficiently advanced to have enabled the Commissioners to fully realise the importance and scientific soundness of their decision. The close analogy existing between land treatment and purification on bacteria beds has already been dealt with, and it should be remembered that, after all, the trend of present bacterial processes is really to revert to principles which were unconsciously relied upon nearly fifty years ago. The work now accomplished, however, in bacterial purification, is of a very different order to that

formerly done in the absence of modern bacteriological knowledge, inasmuch as the true principles underlying Nature's universal method for the reduction of waste and polluting matters were not only very imperfectly understood, but, as shown by the results in many recent channels of research, were very largely unknown. The general improvement in scientific apparatus and methods of research has largely contributed to the mass of knowledge now accumulating in regard to the biology of sewage purification. Modern improvements in the high powers of the microscope, tending to clearer definition and illumination of the objects viewed, has enabled the mysterious workings of microbic life to be watched with a scrutiny not hitherto possible. The chemist has for years struggled with the problems of sewage purification, but, beyond attaining clarification of the liquid portion of the sewage, his efforts in this connection cannot be regarded as successful. The clear chemical effluent, with its high percentage of dissolved impurities and consequent liability to subsequent putrefaction, is well known to all who have to deal with the subject of sewage purification. In this connection, too, arises that most troublesome and prohibitively costly business of sludge pressing and sludge disposal. In the case of the sewage of the metropolis, although the precipitation is not carried to a very high point of perfection, the quantity of sludge yearly sent to sea is considerably over 2½ million tons, and would cover Hyde Park (an area of 400 acres) to a depth of about 5½ ft. Its disposal involves a fleet of six sludge steamers making over 2,600 journeys to sea to and from Barrow Deep, a distance of 100 miles, or a total distance during the year of 260,600 miles, being equal to a journey of nearly 10½ times round the world. As with London, so also has been the sludge difficulty of practically every provincial town following chemical processes of clarification, more or less according to the quantity of sewage dealt with and the local facilities for sludge disposal.

It is from the bacteriologist and from the practical sewage engineer that future guidance is to be sought in the work of sewage purification, whilst the chemist will check, as heretofore, the chemical purity of the effluents sent off, and so add to our knowledge in respect of the exact changes brought about in the sewage by the different classes of organisms upon which the work of purification depends.

This leads us to the verge of several lines of inquiry possessing the fullest interest to the scientific mind, and in respect of many of which much original work still remains to be done. It is, for example, of the greatest importance to know the exact nature of the operations of the bacterial life contained in the fresh sewage, in the septic tank, and in the contact or percolating bed. The conditions most favourable to the development of each class of organism required for the different stages of purification must be closely sought out in order that those conditions may be borne in mind in the design of the bacterial purification works. The advantages and extent of the possibility of separating the different classes of organisms is a subject into which further inquiry may well be made. That is to say, how far is it possible, or desirable, that the preliminary preparation of the sewage in the septic tank should be wholly anaërobic or its subsequent treatment on the contact or percolating bed brought about solely or mainly upon aërobic lines.

Another point of much importance, too, and one which probably requires independent determination for the different classes of sewage dealt with, is that of the extent to which septic conditions should be carried before the final purification should be commenced. An over-septicised sewage has been found to be less amenable to subsequent treatment in the latter stages of the process. This question also has a practical bearing on the capacity of septic tank required and the most suitable length of stay of the sewage therein.

The relative advantages of long and short periods of contacts respectively and the rapidity with which nitrification takes place are matters receiving practical investigation at a number of bacterial works.

The choking and failure of many of the earlier bacterial beds put down has been shown by later experience to be due to the use of crude sewage upon the bed, the improper grading and screening of the materials, insufficient aëration, and inadequate under-drainage. The teachings derived from instances where such troubles have been experienced should afford invaluable guidance in the construction of beds of a more recent date.

The controversy in respect of the preference to be given between the mode of final treatment on contact and on percolating beds respectively will perhaps never be absolutely determined in universal favour of either one system or the other; but local circumstances will doubtless always enter largely into the decision in any given case. At the moment the tendency is in favour

of the percolating bed and the revolving sprinkler; but further experience as to comparative capital and working costs and practical working results is wanting.

In contemplating the laying out of a new scheme of bacterial works it is a common mistake, especially amongst those not technically conversant with the subject, to follow on the lines of processes successfully in use elsewhere. This may or may not be a desirable thing to do in any given case. The fact, however, must not be lost sight of that sewage is by no means a standard liquid of uniform composition, and always equally amenable to a uniform treatment. Sewage is, in fact, most variable in its composition, not only in different towns, but during different hours of the day in the same town. At one time it may be a dilute liquid, at another strong; it may or may not contain numerous varieties of manufacturer's waste liquids, brewery or tannery refuse, and numerous other matters affecting the precise nature of the treatment required for its purification. Although the possibility of satisfactorily dealing with such variable liquids upon bacterial lines was open to considerable doubt, later experience and practical trial has repeatedly shown that bacterial processes admit of considerable elasticity in the reduction of polluting matters, but at the same time it is a very essential precaution before preparing any extensive scheme, to instal, if possible, small experimental beds for the purpose of observation and test of the particular sewage to be dealt with. Much information of practical value will follow from such a course: it will, for instance, be possible to ascertain the most suitable rate of treatment through the bed, the extent of the tendency to choke and the means necessary to avoid the difficulty, the necessity for preliminary screening and precipitation of road grit, the quantity of suspended matter in the effluent and the necessity or otherwise of further treatment before passing into the stream. In any important scheme practical observations on these general lines will usually well repay the preliminary outlay on experimental beds, more especially as it is generally quite possible to so lay out such preliminary works in a way that they may be incorporated in the general scheme and afterwards permanently used.

A point of importance, which has been referred to at some length in these pages, is that of the bacteriological condition of the effluents sent off from bacteria beds. It has been shown that a high degree of chemical purification ensuring an effluent of a satisfactory and permanent character is obtained, but that bacteriologically the effluent cannot be considered safe to discharge into streams from which water is taken lower down for drinking purposes. This is a question to which further attention will doubtless be directed in the future, particularly as many towns still obtain their water supply from watercourses to which sewage gains access. Such dangers as may exist from these conditions do not, however, appear to materially differ from those which have obtained, and still obtain, in respect of effluents from land treatment as officially insisted upon for so many years past, inasmuch as sewage is not modified in its biological character to any material extent by treatment on land.

The progress of modern sanitation is directing increased attention to the question of rivers pollution and prevention and requirements involving higher standards of purity, or additional means for preventing the access of polluting matters, have been officially foreshadowed. How far it is practicable to insist on the purification of "storm waters," the first flush of which is admittedly oftentimes found to be quite as impure as much of the "sewage" which arrives for treatment, is a question which will receive increased attention in the future, and is one requiring to be carefully borne in mind in the design of new schemes.

In reviewing the present position of the sewage disposal problem, although the question has received prominent attention throughout the past half-century, it must be remembered that it is only during the past decade that real progress in the investigation of the principles underlying the purification of polluting matters has been made, and that the practical treatment of sewage upon bacterial lines is therefore as yet in a comparatively early stage of development. But it has been shown that much indeed has already been done which augurs well for the future, and in the present condition of bacteriological knowledge, no one will probably venture to suggest a limit to the possibility of still further adapting the conditions in new works for the bacterial treatment of sewage to the more favourable carrying on of the process and to the ultimate production of an effluent which shall, both bacterially and chemically, satisfy the most critical aspirant to a counsel of perfection in the purification of the water-courses of this country.

Speed Regulation of Engines.

By G. JAMES WELLS, Wh.Sc., Assoc.M.Inst.C.E., M.I.Mech.E.

In order that the problem of speed regulation may be adequately treated, it is necessary that the varying relations between the external load and the working fluid be examined in detail, so that a thorough grasp of the problems may be obtained, and the designer enabled to discriminate between the possible and the impossible portions of the result desired.

The external load may be dealt with very briefly, as usually it is quite beyond the control of the engineer, and only a rough idea can be obtained of its characteristic variations. In dealing with a power station one has generally to be content with such information as its normal maximum value, and the greatest overload that the engine will have to deal with. Further, it is often stipulated that the whole normal load may be thrown off suddenly, or *vice versâ*, the maximum load thrown on at once, and the engine must deal with the situation without its speed varying beyond certain limits.

For factory purposes the load is much steadier, the variations being much more moderate in amount, whilst the speed may vary through a somewhat larger range without trouble. A special "knock-off" gear is added to deal with exceptional cases, but this is a gear for emergencies.

From these considerations it is clear that the variations of the external load are irregular, and their occurrence cannot be predicted under ordinary working conditions. They are "non-periodic."

The turning moment of all reciprocating engines must be irregular, in consequence of the effect of the angularity of the connecting rod and the expansive use of the working fluid. The actual causes of variation of the turning moment can be divided into four sections for convenience of treatment.

(1) Variations of pressure in the cylinder due to the expansive use of steam.
(2) The effect of the angularity of the connecting rod.
(3) The effect of inertia of the reciprocating parts.
(4) The action of the governors, which by reducing the initial pressure, or altering the point of cut-off, changes the shape of the turning moment curve.

If these effects are briefly considered they will be recognised as having a "periodic" character, that is, the variations are exactly reproduced in successive periods, and are thus quite unlike the fluctuations of the external load.

Causes (1) and (4) may be considered together, selecting the extreme cases of each for examination. The extremes are evidently the full and friction loads, for which the turning moments must be determined.

Assuming that about 8 per cent. of the full load is equal to the friction or light load of an engine, giving 1,500 I.H.-P, with an initial steam pressure of 150 lbs. at the engine, the total mean effective pressure being 30 lbs. per sq. in., then the probable indicator cards for full load would be as shown in Fig. 1, whilst the friction load card would be something like that shown in Fig. 2, giving a mean effective pressure of about 3 lbs.

Next, by either of the well-known methods, inertia pressures and the effect of the connecting rod must be found and allowed for, so that the nett effective turning moment can be plotted as a diagram for a complete period. For the full and light loads under

consideration, Fig. 3 shows the final curves, which are drawn for a complete revolution, when the cycle of variations will be again repeated. It should be noticed that the external load is assumed to remain constant for the revolution under examination.

The dotted line drawn parallel to the base represents the mean ordinate, and is the mean moment of resistance due to the action of the full load. *A B C D E* is the curve of turning moment for full load, and *A F C H E* the curve for light load.

The orthodox method of computing the weight of the fly-wheel is to take the maximum excess or defect of area between the horizontal line and the turning moment curve, and find the weight necessary to prevent the speed exceeding the prescribed limits, when the energy represented by these areas is absorbed or withdrawn from the rotating wheel.

In order that the engine may be kept within the limits of speed it is necessary to do more than consider the maximum area of defect from the mean resistance, for it is obvious that if, when the engine is running at normal speed under full load, the whole load is thrown off, then the maximum area of excess energy is very much greater, which leads to a proportionately heavier wheel or the speed must of necessity rise beyond the prescribed limits. Similarly it is obvious that an engine running at normal speed without any external load, having the full load suddenly imposed, will have a much greater area to deal with than that considered in the orthodox way. This part of the subject will be referred to again at a later stage.

In practice it is customary to provide a wheel having a mass proportioned to the total amount of external work done per revolution, the ratio or factor employed being varied according to the nature of the external load, and the type of engine employed. The magnitude of this factor represents the compromise between unsteadiness and the commercial and practical objections to a very large wheel.

It is obvious that the periodic variations of speed can be kept within any prescribed limits by the use of a sufficient mass in the wheel, and that this limitation of fluctuation depends entirely upon the fly-wheel.

Taking off or adding to the external load, completely alters the balance between the mean turning effort and the external load, and it is necessary then to have some means of readjusting the balance by reducing or increasing the supply of the working fluid. This is

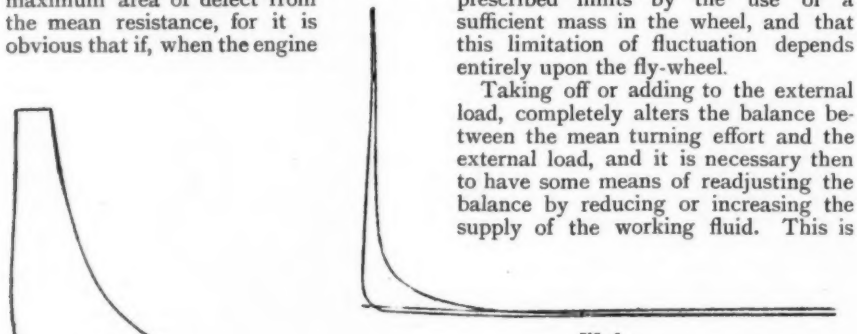


FIG. 2.

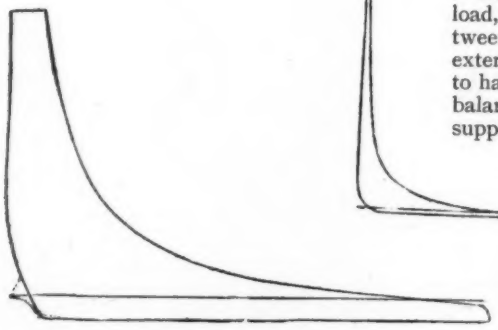


FIG. 1.

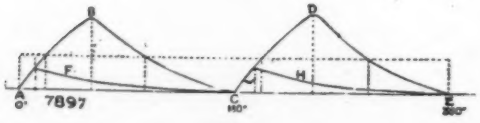


FIG. 3.

the function of the governor, *i.e.*, the continual re-adjustment of the supply of energy to maintain the mean effort of the engine equal to the mean resistance.

The majority of engine governors are modifications of the original Watt pendulum governor, which is based upon the rotating pendulum. The simple "rotating pendulum" is shown

in Fig. 4. The axis of rotation is necessarily vertical, and if we consider the ball to be rotating at a steady speed of N revolutions per minute the height of the cone described by the ball and its supporting string is

$$= \frac{35^2 35}{N^2}; \text{ inches,}$$

that is, the height depends absolutely upon its angular velocity, and for any other velocity the height varies inversely as the speed, the weight of the ball may be anything.

Practically except at very low speeds this form of governor is impossible because the height is too small, and there is also lack of sensitiveness. For any particular speed of rotation, there is some corresponding height, hence it is important to know the rate of change of height with any given rate of change of speed, for it is obvious that technical reasons demand that the change of height shall have its convenient value.

Let $\frac{1}{a}$ = the fraction of the mean speed equal to the difference between the mean speed and the maximum and minimum permissible. Then if $\Delta h =$ difference of height, and $h =$ the height when running at mean speed, then it may be shown that

$$\frac{\Delta h}{h} = \frac{2}{a} \text{ very nearly,}$$

or the fluctuation of height is equal to twice the fluctuation in speed. Suppose that the variation of speed specified is 5 per cent. then $\frac{1}{a} = \frac{1}{20}$ and the ratio

$$\frac{\Delta h}{h} = \frac{2}{20} = \frac{1}{10}$$

and if $h = 10$ inches the governor mechanism would have to be so arranged that a vertical rise of the walls of 1 in. must suffice for the movement of the controlling gear through its whole range.

The "Porter" or loaded type of governor provides a means of increasing the height for a particular speed, and as a consequence the absolute variation of height required for the controlling gear

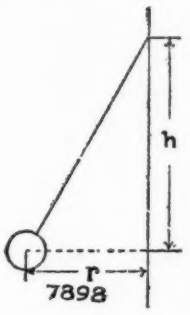


FIG. 4.

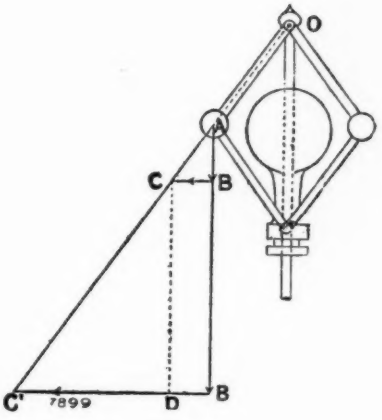


FIG. 5.

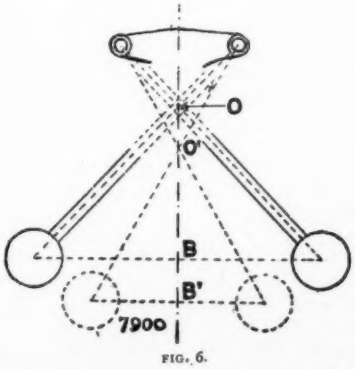


FIG. 6.

is correspondingly increased. Such a loaded governor is shown in Fig 5, and the height

$$= \left(\frac{w + W}{w}\right) \frac{35{,}235}{N^2} \text{ inches,}$$

where w = weight of each rotating ball, and W = weight of counterpoise or central load. Thus by making the ratio $\frac{W}{w}$ large the height is increased and the ratio $\frac{\Delta h}{h}$ becomes smaller, and consequently $\frac{1}{a}$ is reduced, that is, the sensitiveness may be increased very materially. By loading the governor its sensitiveness may be increased to any reasonable extent, but it can never become isochronous, for it is obvious that some alteration in height is unavoidable, and a governor to be isochronous must have the same height for all positions of the balls.

One of the properties of the parabola is that its subnormal is a constant quantity, hence governors have been designed in which the balls are constrained to move in a path approximately parabolic in form. A very common form for this type is known as the crossed arm, and is shown in Fig. 6. Probably the easiest way to design this governor is to first set out the parabola, select convenient positions for the extreme range of movements of the balls, then normals should be drawn to the curve at these points, and where they intersect will be the centre for a circular arc closely approximating to the desired curve.

Messrs. Galloway have used a governor in which the balls move along a parabolic curve, and other firms have used designs obtaining a similar result.

If the governor was truly isochronous the least change of speed would cause it to move up or down through its whole range, and because such changes of speed are constantly occurring, the governor would be in constant movement, or hunting about, so that the throttle would be either wide open or shut, and the speed of rotation constantly rising and falling, due to the governor exaggerating the adjustment of the steam supply necessary to preserve the balance between the effort and resistance.

Engineers usually design their governors to have the maximum sensitiveness possible and then add some artificial resistance to reduce it so as to avoid the defect of hunting. The better way surely is to design the governor with the necessary stability and avoid brakes, resistances, dash-pot, &c., as a redundant member of the mechanism, costing money to design, manufacture, and to maintain.

A very convenient way of examining the relative merits of pendulum governors is to construct the diagram of forces for the equilibrium of the ball in any position. For example let $O\,A$ in Fig. 7, represent the position of the ball arm running steadily, the weight of the ball is represented by $A\,B$, and the centrifugal force $B\,C$, and $A\,C$ = pull in arm. Now let the governor be loaded with a central mass so that its effective weight at the ball centre $= B\,B'$, the centrifugal force is unaltered in magnitude and $= B'C'$ then the tension in arm must $= A\,C'$ and the ball arm must take a position $A'O$, such that $A'O$ and $A\,C'$ are parallel. The height of the governor has been increased therefore from $O\,D$ to $O\,D'$ and it is clear that

$$\frac{O\,D'}{O\,D} = \frac{A\,C'}{A\,C};$$

that is, the height is, increased in direct proportion to the increase of weight.

Hitherto no account has been taken of the influence of the resistance due to the friction of the mechanism, and by means of these diagrams it is easy to understand its effect upon the governor. Since friction always opposes motion, if in Fig. 8 the condition of steady speed is shown by the position of the ball arm and by the triangle of forces $A\,B\,C$, then if the frictional resistance $= B\,B' = B\,B''$ on the same scale that $A\,B$ = weight of the ball and load. If more load should come on to the engine, the speed will

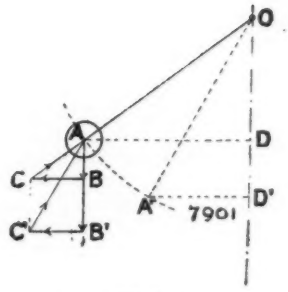


FIG. 7.

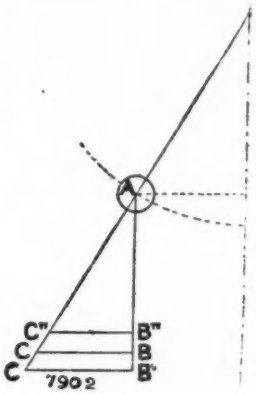


FIG. 8.

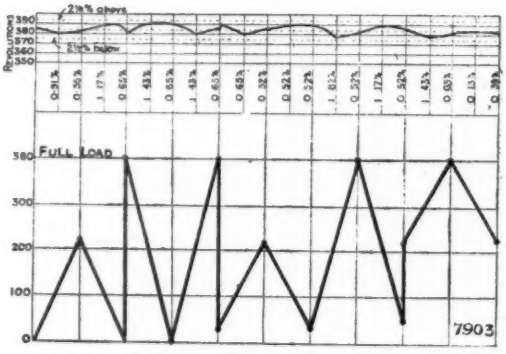


FIG. 9.

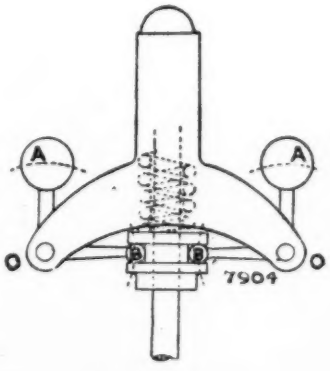


FIG. 10.

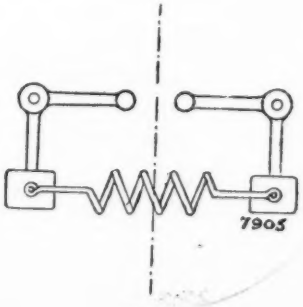


FIG. 11.

FIG. 12.

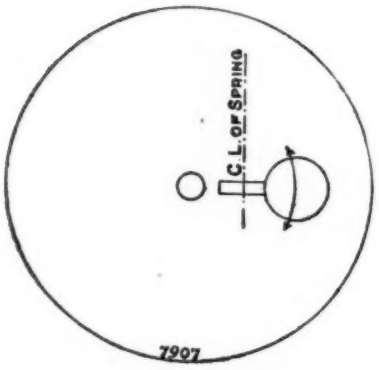


FIG. 13.

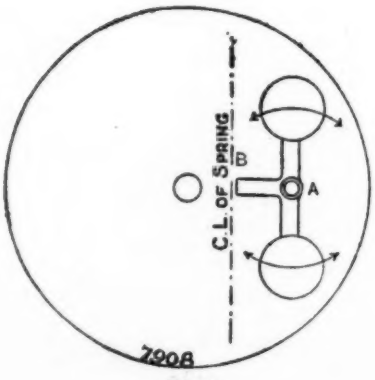


FIG. 14.

fall until the centrifugal force has been reduced to $B'' C''$ before the ball can commence to move downwards; similarly if the load be reduced the engine will increase in speed until the centrifugal force $= B' C'$, when the balls will be just able to commence moving upwards. Hence the ratio of $A B$ and $B B'$ or $B B''$ is a measure of the powerfulness of the governor, and another advantage of the loaded governor is here apparent.

This will be more apparent if a numerical example be taken. Let N_1 = the maximum number of revolutions, corresponding to the centrifugal force $B' C'$, and N_2 = the minimum number of revolutions corresponding to the centrifugal force $B'' C''$, whilst N = number of revolutions corresponding to the centrifugal force $B C$, then

$$N_1 = N\sqrt{\frac{B' C'}{B C}}; \text{ and } N_2 = N\sqrt{\frac{B'' C''}{B C}};$$

$$= N\sqrt{\frac{A C'}{A C}} \qquad = N\sqrt{\frac{A C''}{B C}};$$

Let $A C$ = 40 lbs., and the resistance $C C'$ or $C C''$ = 10 lbs., then the ratio of the speed may increase before the governor will respond

$$= \sqrt{\frac{50}{40}} = \begin{matrix} 1{\cdot}118, \text{ say } 12 \text{ per cent.} \\ \text{increase,} \end{matrix}$$

and the ratio in which the speed may decrease

$$= \sqrt{\frac{40}{30}} = \begin{matrix} 1{\cdot}154, \text{ say } 15 \text{ per cent.} \\ \text{decrease.} \end{matrix}$$

Now let the governor be loaded with a weight of 80 lbs. and these ratios of increase and decrease become respec tively 4 per cent. and 4·4 per cent. If the frictional resistance remained constant, the speed of the engine might be permanently increased or decreased within those limits without any movement of the governor taking place. But practically the thrust or tension due to the load on the controlling gear varies during each stroke, the frictional resistance will be a variable one, and the delay in governor action will be reduced or increased proportionately.

Another important source of retardation of movement is due to the inertia

of the total mass of the parts set in motion. This may be in very large governors a serious item. It is an easy—although possibly tedious—problem to solve. All the masses should be reduced to their equivalent at the collar say, and then the acceleration determined from the force available for the purpose.

Take the case of a governor with a movement of the collar of about $1\frac{1}{2}$ ins. for a reduction or increase of half load, and suppose the counterpoise, attachments, and spindle amount to 400 lbs. If the engine be making 60 revolutions per minute, and the cut-off takes place about 33 per cent. of the stroke normally, then the maximum time available is 66 per cent. of the time of one stroke. Now the time of a stroke is one half of a second, and 66 per cent. of this is one third of a second; hence the mass of 400 lbs must be set in motion with a velocity increasing to a maximum and diminishing to zero, prescribing $1\frac{1}{2}$ ins. in one third of a second. Assuming that the rate of acceleration of the mass is uniform for the first $\frac{3}{4}$ in., and that the rate of retardation is similarly uniform for the next $\frac{3}{4}$ in., then the rate of acceleration will

$$= \frac{2 \times 36}{16} = 4{\cdot}5,$$

and the force necessary to produce this will

$$= \frac{400}{32{\cdot}2} \times 4{\cdot}5 = 55{\cdot}9 \text{ lbs.}$$

Of course, this result is put forward only for the purpose of emphasising the necessity for keeping down mass in the design of the moving parts in governor design, if promptness is sought. The figures are not absolutely accurate.

The actual state of affairs is probably something as follows:—First let the engine be running steadily until some extra load is thrown on, then the engine commences to slow down at a rate dependent upon the mass of the fly-wheel, until the governor has increased the steam supply by the required amount to balance the load. So soon as the speed begins to fall the centrifugal force also commences to fall, and equilibrium is destroyed. When the force necessary to overcome friction is available the balls would fall to the new position, but a further reduction of speed is necessary to obtain the force requisite to overcome the inertia of the parts before movement of the gear can commence. It is then probable that momentum will carry the gear a little too far, which will result in a momentary increase of speed beyond the normal, a secondary bad effect of much mass in the gear.

To meet this defect, springs are employed by many designers, for the mass of a spring is small compared with the load it can replace. An advantage of a spring is that by suitably arranging its stiffness, the *stability* of the governor can be assured without the use of any external damping apparatus.

The "Hartnell" type of spring governor has been very extensively used, and with the most satisfactory results in practice. It can be given almost any degree of isochronism desired, with great powerfulness. It can be used in any position, and has been adopted by high-speed engine builders with the happiest results. In Fig. 9 is reproduced the speed diagram in the case of some engines supplied for electric traction purposes by Messrs. Belliss & Morcom, of Birmingham.

The condition of equilibrium in this type of governor, is that the moments of the centrifugal force and of the spring shall balance each other. Using the rotation of Fig. 10 it will be seen that

$$C \times O\,A = S \times O\,B,$$

and as usually $O\,A = O\,B$, this reduces to

$$C = S;$$

The effect of the weight of the arms must be considered, but no definite rules can be given, since the position of the arms varies, and it is a very simple matter to deal with.

In the above equation $C = \frac{w}{g}\frac{v^2}{r}$, in which $\frac{w}{g}$ is a constant quantity, and

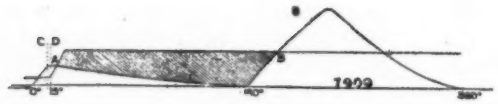


FIG. 15.

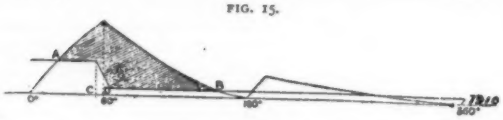


FIG. 16.

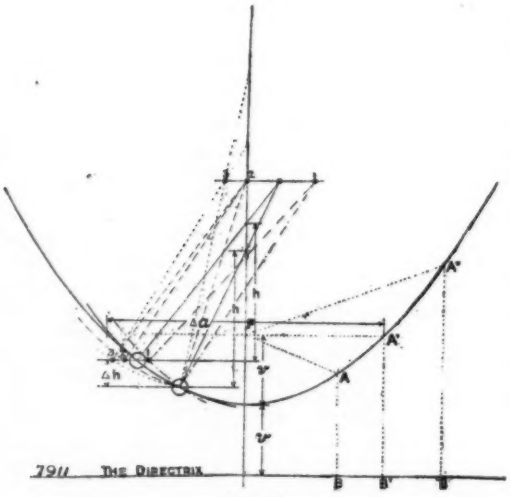


FIG. 17.

$\frac{v^2}{r}$ is proportional to $\frac{v^2}{r}$ or r. The centrifugal force therefore varies as the radius, hence if the stiffness of the spring be such that it increases proportionately to the radius, then the governor will run steadily in any position at the same speed.

In order to obtain stability it is usual to arrange the stiffness of the springs, so that there is a definite position of the collar for any particular speed of rotation.

It is customary with many designers to attach the springs to the balls direct, one on either side, an arrangement that relieves the pins of pressure, and consequently reduces friction. This arrangement is shown in Fig. 11.

Another type of governor operates directly on the position of the eccentric operating the slide valve, and the mechanism is frequently placed in a drum or fly-wheel. Larger weights can be mounted in this way, so that a very powerful governor can be obtained. The only new feature, however, that needs noticing here is the use of the inertia effect of mass in motion, which is often employed in these governors. This will be rendered clear if the three elementary arrangements of springs and weights be considered. The first, illustrated in Fig. 12, the movement of the ball is radial, due to changes of centrifugal force; in Fig. 13 the movement of the ball cannot be affected by centrifugal force, but any increase in speed of the engine, the ball will lag, or if the speed decrease, the ball will over-run the wheel, or lead. This has been termed tangential acceleration, and the former effect radial acceleration.

The third arrangement possible is to pivot the mass at A, in Fig. 14, then any change of velocity of rotation of the wheel will cause the ball to rotate about the pin A, the motion of the tail B altering the eccentricity of the eccentric accordingly. This may be termed angular acceleration. Fly-wheel governors using one or more of these principles are on the market, and excellent results are claimed for them, but obviously the same conditions must be fulfilled by them as in the rotating pendulum type in order that satisfactory results may be obtained.

Summing up the process of arranging for the regulation of a steam, gas, &c., engine, first a turning effort diagram is required, and this must extend through a complete cycle, when (*a*) under full load, and when (*b*) running light. On this diagram a line showing mean resistance

due to full load, also a second line representing the friction load only.

Next, the type of governor to be employed must be selected, and the method of control, either a trip gear, throttle valve, &c., so that the size of the parts can be fixed. Then an examination of the design in detail should be made, so that the combined effects of the frictional resistance of pins and connections, the inertia of the total moving parts, and the actual "pluck" of the "trippers," &c., may be estimated.

With this data available the "time lag" of the governor, may be guessed, and Figs. 15 and 16 constructed. In Fig. 15 the full load turning moment is laid down for half a revolution, and the light load turning moment for the next stroke. Then the mean resistance due to full load is drawn up to a point before cut off, such that the distance $C\ D$ = the time lag of the governor, then the resistance will fall more or less quickly to no load, when the line will again become horizontal. The shaded area must then be measured, as it represents the excess energy that the fly-wheel will have to absorb without its speed exceeding the stipulated limit.

Fig. 16 represents the construction for the similar condition of things when full load is suddenly thrown on, and it is needless to say that the greater of the shaded areas in Figs. 15 and 16 must be taken when determining the mass of the wheel.

When designing a governor it is frequently the case that great efforts are made to obtain great sensitiveness and power, overlooking altogether the effect of the inevitable (as it cannot be eliminated) time lag of the mechanism. The rise of speed between the points *A*. *B*. in Fig. 15 will be such that the regulating gear will over-run its true position, which will lead to a wave on the "Moscrop" record above and below the mean speed. Similarly the fall of speed between *A*. and *B*. in Fig. 16 will lead to an excessive supply of steam with a consequent irregularity in speed until a final settlement has been effected.

Some such effect as this is undoubtedly inevitable, but if this undulatory action is not properly recognised when the design is being settled, its oversight will lead to much trouble when a case occurs of a load varying at some rate which is a multiple of the governor period, when building up will occur until the engine hunts to such an extent as to require attention.

Probably many have experienced this trouble of hunting, and if they have studied "forced vibrations" or "resonance," as electricians call it, they will know that it is necessary to alter the period of one or other disturbance. Sometimes it is effected by putting the dash-pot out of operation, or increasing its effect. In other cases the reduction of the mass of the counterpoise, and altering the speed of the governor has been the cure. Each of these changes alters the "time-lag" in amount, but after a study of Figs. 15 and 16 it will be clear that if the fly-wheel power is *deficient* fluctuation of speed is certain to be large, and the fly-wheel may assist to intensify the undulations occurring.

Irregular running is a very complex question, and can only be successfully solved after the several factors concerned have been carefully studied, and each case of complaint must be separately treated.

The subject of the "regulation of speed" of engines is exceedingly interesting, whilst it is by no means so completely and finally settled as many believe, judging by the trouble it often entails in practice, and this is the reason why the author has ventured to submit the subject for discussion.

[Proceedings of the Manchester Association of Engineers, January, 1907.]

APPENDIX.

Centrifugal force :—

Let W lbs. = weight of revolving mass.
N = number of revolutions per minute.
r = radius of centre of mass in feet.
g = the acceleration due to gravity.
F = the centrifugal force in lbs.

Then $F = \frac{W v^2}{g r} = \frac{W}{g r}\left(\frac{2 \pi r N}{60}\right)^2$;

$= (0{\cdot}00034)\ W N^2 r$;

Let $W = 1$ lb., and $r = 1$ ft., then

$F = C N^2$.

The following Table gives the value of F for values of N from 10 to 99, and other values can be obtained by shifting the decimal point.

From the Table, F for 90 revolutions = 2·75 lbs. for 1 lb. at 1 ft., hence for this case

$F = 2{\cdot}75 \times 20 \times 0{\cdot}75 = 41{\cdot}25$ lbs.

Suppose the speed be increased to 220 revolutions, then F for 1 lb. at 1 ft. = 15 lbs., hence

$F = 15 \times 20 \times 0{\cdot}75 = 225$ lbs.

and the weight of the rim required

$$= \frac{\Delta E \times g}{k V_0^2} \text{ lbs.}$$

Professor Unwin has given as suitable values for k the following:—

	k =
Engines Pumping.	$\frac{1}{10}$
,, Driving Machine Tools.	$\frac{1}{20}$
,, ,, Textile Machines.	$\frac{1}{40}$
,, ,, Spinning Machines.	$\frac{1}{60}$ to $\frac{1}{100}$
,, ,, Electric Generators.	$\frac{1}{120}$

	0	1	2	3	4	5	6	7	8	9
10	·034	·041	·049	·057	·067	·076	·087	·098	·110	·123
20	·136	·150	·164	·179	·196	·213	·230	·248	·266	·286
30	·306	·326	·348	·370	·393	·416	·440	·465	·491	·517
40	·544	·572	·600	·629	·658	·690	·723	·751	·785	·816
50	·850	·885	·920	·956	·991	1·029	1·065	1·104	1·143	1·183
60	1·224	1·266	1·301	1·35	1·39	1·44	1·48	1·52	1·57	1·62
70	1·66	1·71	1·76	1·81	1·86	1·91	1·96	2·02	2·07	2·12
80	2·18	2·23	2·28	2·34	2·40	2·46	2·51	2·57	2·63	2·69
90	2·75	2·81	2·88	2·94	3·00	3·06	3·12	3·20	3·26	3·33

EXAMPLE.—Let the weight of a ball = 20 lbs., and the radius of the circle described be 9 inches, and the speed be 60 revolutions per minute.

Parabola.—This curve is the locus of a point equally distant from a fixed right angle (the directrix) and a fixed point (the focus).

The intercept on a line through the focus parallel to the directrix is always equal to twice the perpendicular distance between the directrix and the focus. See Fig. 17.

On Fig. 17 is shown the effect of change of centre of expansion which will repay examination. The effect of exceeding the proper deviation for the approximate centre of curvative, it will be seen, is to reverse the action of the governor, that is for a decrease of h, the balls must fall.

Fly-wheel Formulæ.—The total amount of energy absorbed by a fly-wheel during a change of speed from V to V_1 ft. per second

$$= \frac{W}{2g}(V_1^2 - V^2) \text{ foot, lbs.}$$

This quantity is the maximum area of excess or defect shown in Figs. 15 and 16, and may be called ΔE.

But $(V_1 + V) = 2 V_0$ where $V_0 =$ mean velocity, and if $kV_0 = (V_0 - V)$ then

$$\Delta E = \frac{W}{2g}(V_1^2 - V^2) = \frac{W}{2g}(V_1 + V)(V_1 - V)$$

$$= \frac{W}{2g} 2 V^0 k V_0 = \frac{W}{g} k V_0^2;$$

If the rim be of cast iron, the area required in square inches

$$= \frac{W \times 0{\cdot}051}{R};$$

where $R = \frac{R_1 + R_2}{2}$, that is the radius of the centre of gravity of the section.

Stress in lbs. per square inch section of rim due to centrifugal force for cast-iron

$$= 0{\cdot}001064\ N^2 R^2;$$

where N = number of revolutions per minute, and R = mean radius of rim in feet.

Where a series of engines are being built, having the same steam distribution, and, therefore, having similar variations of turning effort, it is convenient to base the weight of rim upon the work done per revolution. Let E = work done per revolution at full load, and n some number such that $n E = \Delta E$ then

$$n E = \frac{W}{g} k V_0^2$$

or the weight W

$$= \frac{g n E}{k V^2_0};$$

but g and n and k are constants for the case under consideration, hence if $\frac{g n}{k} = F$

$$W = F \frac{E}{V^2_0};$$

and the quantity F is frequently called the fly-wheel factor.

Where an existing engine is being replaced by another, it is necessary to discover the relative fly-wheel powers, and this factor method is convenient, since

$$\frac{F_1}{F_2} = \frac{W_1 N_1^2 E_2}{W_2 N_2^2 E_1},$$

where the subscripts denote either engine, numbers one or two respectively. Remembering that W is proportional to volume, the ratio of the factors may be readily determined, and a comparison of the probable steadiness of turning of the two engines made.

The formula

$$\Delta E = \frac{W}{2g}(V_0^2);$$

may be written thus

$$\Delta E = \frac{W N^2 R_0^2}{5{,}874}.$$

Where R_0 = radius of gyration of rim in feet; then for any wheel $WR_0^2/5{,}874$ is constant. The useful relationship follows

$$\Delta E = \frac{W R_0^2}{5.874} \times N^2.$$

Suppose $WR_0^2/5.874 = 50$ for some wheel, then if the engine makes 100 revolutions per minute the total energy stored

$$= 50 \times 100^2 = 500{,}000 \text{ ft. lbs.}$$

Again, if the normal load of the engine is 120 H.-P. at 100 revolutions, and the fly-wheel has to absorb the work done in one revolution, what would be the increase of speed?

Work per revolution

$$= \frac{120 \times 33000}{100} = 39{,}600 \text{ foot lbs.};$$

hence the total energy in wheel will be increased to 539,600 foot lbs. and

$$N = \sqrt{\frac{539600}{50}} = \sqrt{10792}$$

$$= 103{\cdot}8 \text{ per minute:}$$

an increase of nearly 4 per cent.

Admission and Exhaust Valves used in Petrol, Gas, and Oil Engines.

IV.

By EDWARD BUTLER, M.I.Mech.E., A.I.E.E.

(*Continued from page* 23.)

In large power engines for using producer-gas and the like, the admixture of the gas and air is conveniently effected by special forms of admission valve, which is for this purpose provided with an annular supply, or with a ported piston on its stem. In some cases the piston and valve are actuated by independent mechanism; the ported piston, for instance, in some cases, being given a trip cut-off action by which the supply of gas is controlled independently of the air by the governor. In the "Cockeril" admission valve, there are two seats, one being exposed to the cylinder pressure; gas is supplied at G (see Fig. 22) and air at A, which enters the cylinder in an annular column surrounding a central column of gas. The valve is arranged contrary to usual practice at the bottom of the cylinder alongside the exhaust valve and is given a cut-off motion by an eccentric trip-gear; the supply of gas being independently controlled by a throttle valve.

In the "Premier" engine the supply of gas is controlled by a ported piston connected to the actuating rods S (Fig. 23); by this means the admission of gas is entirely independent of the air supply. In the position shown the air ports are open to the air passage A; this permits of the valve V being opened for a full supply of air for flushing purposes, for instance, or in case of a cut-out charge by the governor. Now, by the depression of the rods S and ported piston, the air ports are partially closed and the communication with the gas supply opened up; the ported piston fitting against a seat to close the passage from

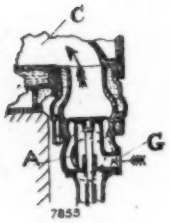


FIG 22.

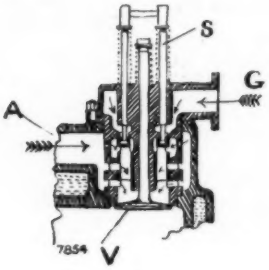


FIG. 23.

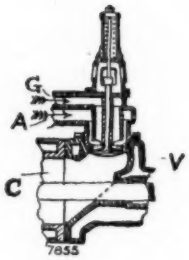


FIG. 24.

the gas at *G*, unless depressed by the rods *S*, thus also preventing air being blown down the gas pipe, as when a flushing charge is being pumped into the motor cylinder. It is important in engines using producer-gas, and even more so with furnace-gas, for the valve to be capable of supplying a full air-charge without throttling action when the supply of gas is either completely or only partially cut off, owing to the large proportion of gas used to form an explosive mixture.

In the admission valve for the "Körting" type of 2-cycle engine, which is arranged on the cylinder top, as shown by Fig. 24, the valve has only one seat; both gas and air are, however, supplied to it by separate charging pumps, air entering, as in Fig. 22, in an annular column with the gas charge down the centre, the valve *V* being controlled by a lever spring and eccentric on a side shaft. By an arrangement of valves on the charging pumps, immediately after the release of the exhaust pressure by the motor piston, an air charge is first driven in which clears the cylinder of burnt gases and escapes by the belt of exhaust ports around the cylinder. In this period the motor piston advances and closes the ports when the gas and air charge is forced in without incurring any loss by escaping with the exhaust.

As before described, the method adopted for the admission of the charge of gas and air in the double piston 2-cycle engine is by ports controlled by one of the motor pistons, no valve being required on the motor-cylinder. The charge is, however, supplied by separate air and gas pumps arranged to clear out the cylinder by an air charge in advance of the mixture supply of gas and air. In order to prevent loss of power from a throttled governing supply of gas, or gas and air, to the charging pumps in large engines of the 2-cycle class, the pumps are always allowed to work on full supply, the delivery to the motor cylinder depending on a governor controlled by-pass between the delivery and suction pipes.

The construction of a successful combined admission and exhaust valve for large power engines has engaged the attention of many engineers, the aim in all cases being simplicity and efficiency in the design and working of the engine. One of the earliest of these single valves is the "Fielding" valve illustrated by Fig. 25. This, as in most cases, is a poppet with a controlling valve or piston on its stem, and works in a similar manner to the valves illustrated by Figs. 6, 7 and 9, which are specially designed for high speed automobile engines. The combination valves now being described have been designed for use with large power engines, some of which are balanced and water-cooled. Referring to Fig. 25, the pressure valve *V* is provided with a hollow piston or poppet *P*, shown in position for admitting the charge of gas and air from the inlet passage *A*, which passes up through the valve and into the combustion chamber under the valve *V*. The hollow poppet is closed to the exhaust outlet *X*, being held up to a seat in

the exhaust chamber by the spring *G*. During the exhaust stroke of the motor piston, the pressure valve *V* is raised to an intermediate position, where the neck of the hollow valve is closed by the valve *V*; the hollow valve in this position being depressed off the seat below the neck so opening communication from the motor cylinder to the exhaust outlet. This form of valve requires a two stage lift as shown in dotted lines, and should be a free sliding, yet gas-tight, fit between the intake and exhaust chambers.

In the "De Boutville" combination valve shown in Fig. 26, an ordinary pressure poppet is used, the space on the underside of which is controlled by two cam opened poppets; one being open during the exhaust stroke, and the other during the admission stroke. Each of the three valves are arranged in line and are equally accessible. Referring to Fig. 26, *V* is the pressure valve open to the combustion chamber *B*, and *T* is a light poppet interposed between the valve *V* and the exhaust outlet and is shown open. During the admission stroke the valve *T* is closed and the valve *N* is opened. It will be seen that this combination is neat and has only one valve exposed to cylinder pressure, and as this valve acts as an admission valve it is cooled to a considerable extent and can be used for a cylinder of 18 ins. to 20 ins. diameter without having to be water-cooled. The drawback to this arrangement is the large space under the valve *V*; consequently the contents are wasted at each exhaust stroke.

In the combination shown by Fig. 27 a pair of valves are arranged one over the other, the upper valve serving as an admission valve and also to balance the exhaust valve. This combination is very ingenious, simple, and accessible, but has two seats exposed to the cylinder pressure. In action the cam lever *M* lifts both valves during the exhaust stroke, when, during the admission stroke, the valve *T* will be closed by its spring, and the valve *N* held up by the cam lever *K* for the passage of gas mixture from *A* to the combustion

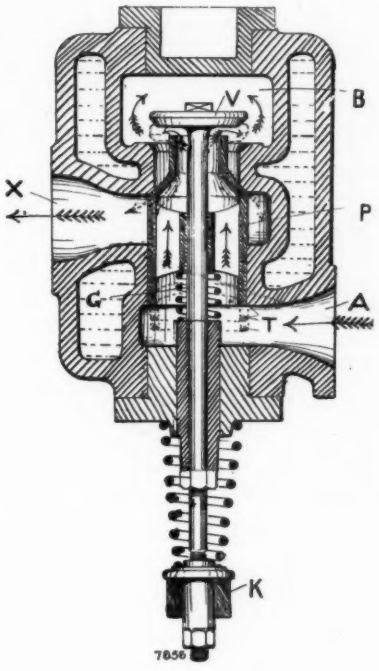


FIG. 25.

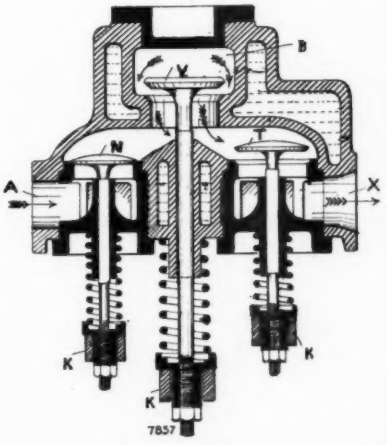


FIG. 26.

chamber *B*, *via* the hollow balancing or piston stem of the valve *N*, which is provided with packing rings as in the case of the balanced exhaust valves, Figs. 19 and 20. This valve, as in Fig. 26, is cooled by the inrush of the gas mixture.

The valve illustrated by the sectional drawing (Fig. 28) has been designed for larger engines, and is water-cooled. In this case the exhaust valve *T* is cast together with a balancing piston head in the usual way, but instead of this piston fitting in a cylinder formed in the valve case, as in Fig. 20, the head of the exhaust valve fits gas-tight in the cylindrical admission valve *N*, the space between the head of the valve *N* and the bottom of the piston *P* being utilised for enclosing a long spring which serves to keep both the admission and the exhaust valve on their seats. A detachable cover is used to guide the valve *N*, and to serve as its seat. Both valves are water-cooled and balanced against cylinder pressure or suction by the telescopic action shown, and are independently opened by the two cam levers *K* and *M*. The cooling water enters by gravity from the small service pipe *W*, and maintains both the stem and piston head of the exhaust valve always full of water, the overflow escaping by the central tube to the outlet nozzle at *W*, and, as will be seen, both the inlet and outlet streams of cooling water are exposed to observation, thus providing against accidental stopping of the supply, any shortage of water forewarning the attendant a considerable time before attaining the danger point of overheating by the visible escape of steam. The two valves can be removed, either singly or together, for examination in a similar manner as obtaining in the common

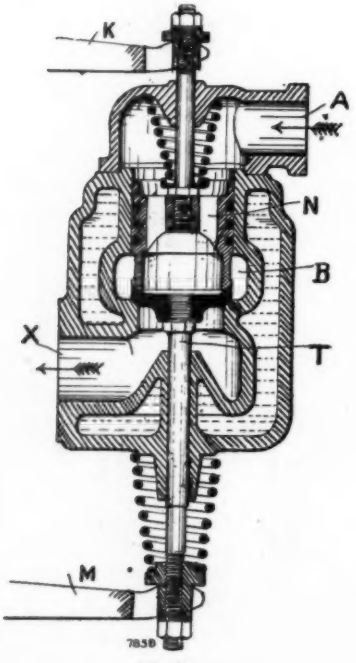


FIG. 27

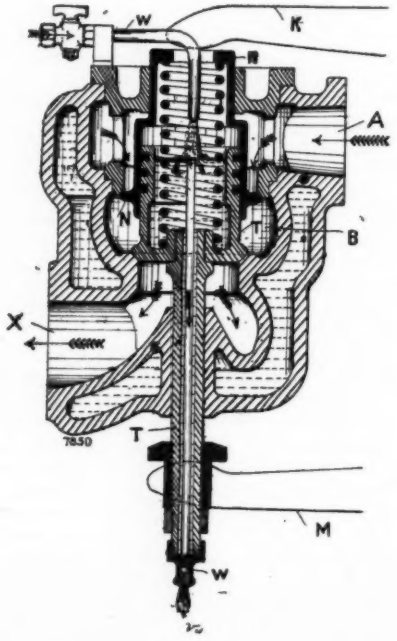


FIG. 28.

superposed arrangement of inlet and exhaust valves as shown by Figs. 2, 3, and 15.

In order, however, to provide a very large area of valve opening, approaching to well over one-seventh of the motor piston area, the double seated balanced combined admission and exhaust valve illustrated by the sectional drawing (Fig. 29) has also been designed by the author. In this valve there are two seats, both the top and undersides of the double seated valve being open to the cylinder by the portways *U*. The valve *V* is held open during both the admission and exhaust strokes by the push-rod *K*, this particular arrangement being adapted for a vertical engine. The inlet and outlet of mixture and exhaust is controlled by the piston valve *T*, which is actuated either by an eccentric or crank on the half-speed cam shaft, by the rod *D*. In the position shown, both valves are open for the admission of gas mixture from the inlet at *A*, and through the port openings in the liner for the piston *T* to the space *E*, communicating to both seats of the pressure valve *V*, and thence by the two passages *U* to the combustion chamber *B*. During the exhaust stroke the valve *V* is retained in the open position as shown; all the change being necessary is for the piston *T* to be moved to a position shown by the dotted line *M* when the cylinder is placed open to the outlet at *X*. Both valve and piston are water-cooled by a gravity feed as in Fig. 28, the water entering by a visible stream feed and escaping into the drain pipes *W*. The valve *V* is cast in one piece with a hollow stem at each end, which are both provided with packing rings, as in the case of the balanced piston head used in the valves 18, 19, 20, 27, and 28; the valve *V* being readily accessible and easily removed for examination at any time without having to interfere with the actuating mechanism in any way, the retaining spring being held down under compression by the cover over the valve, and thus, to a great extent, simplifies removal and the appearance of the engine. The same method of cooling is adopted as in Fig. 28, by which the valve is always kept full of water, there being no glands used or possibility for leakage, and in this way the risk of running the engine for such a time as may cause overheating by failing to turn on the water supply, or through accidental stoppage in the circulation is entirely avoided, the valve being at all times full to overflowing, and so arranged as to give timely warning of an insufficient supply.

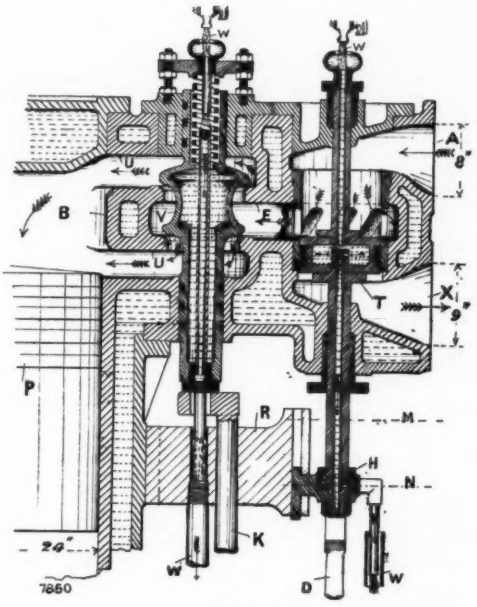


FIG. 29.

(To be continued.)

RAILWAY ENGINEERING NOTES.

A Rotary Snow Plough.

It is seldom that snow drifts occurring in this country are sufficiently heavy to block the lines, but when they do occur the difficulties experienced in effecting a clearance may be sufficient to cause considerable inconvenience, as the recent isolation of the town of Aberdeen demonstrates.

In countries where snowfalls are heavy and continuous, and blocks therefore are of frequent occurrence, adequate means must be provided for keeping the roads open. The old and time honoured method of tracking a 15 ft. to 20 ft. drift by means of a wedge plough and six or seven heavy locomotives, was attended with many difficulties and danger to the men in charge of the operations, and more often than not resulted in one or more of the locomotives becoming derailed and several men being injured.

FIG. 1.—SHOWING THE LINE AS CLEARED BY THE ROTARY PLOUGH.

The introduction of the rotary plough, however, rendered the work of clearance easy, and accomplished much saving in time besides eliminating the danger element. It will bore its way through the most densely packed and hardest frozen drifts and generally the power required for its propulsion can be adequately provided by one, or at the most two, heavy locomotives.

The machine forming the subject of the illustration opposite is the largest ever built and has recently been completed for the Denver, North Western and Pacific Railway by the American Locomotive Company. It is capable of taking a cut 13 ft. 4 ins. wide. The wheel consists of 10 cone-shaped scoops, fitted with knives which adjust themselves automatically into cutting position. The wheel is encased in a drum, which is provided with a reversible hood operated by an air cylinder, so that the hood may be turned to either side to suit the direction in which the wheel is turning. The boiler is of the locomotive type, with "Belpaire" fire-box. The engine consists of two horizontal cylinders with slide-valves operated by the "Walschaert" valve gear. The plough is carried on a steel I-beam frame, and is mounted on two 4-wheel steel frame trucks. To prevent the derailment of the plough, the front truck is provided with ice cutters and flangers. The ice cutters are attached to a frame hung on the forward end of the front truck and operated by means of an air cylinder,

so that it may be raised and lowered in crossing frogs or switches. The flangers are hung in the rear of the truck and connected to the axle, and are also operated by an air cylinder. With the ice cutter and flanger in perfect working order, it is absolutely impossible for the rotary to be derailed by ice or snow.

The rotary has been used on most of the American transcontinental railways for the past twenty years, and the successful operation in winter of many of the lines crossing the Rocky mountains has depended upon these devices for fighting snow.

The Euston and Watford Electric Line.

THE London & North-Western Railway scheme for an electric railway partly under, partly alongside and partly deviating from the existing main line between Euston and Watford, is the most important and interesting of the British railway promotions of the present Session. It involves an estimated expenditure, for construction, of £2,193,842, which does not include the cost of the generating station or electrical equipment. The company also intends to widen part of the Rickmansworth branch, which joins the main line near Watford on the London side, at a cost of £69,714, and the Croxley Green branch at an estimated cost of £72,856. The total length of new line involved is about 20 miles, of which about 2¾ miles will be in tube.

The new station, which it is proposed to construct under the existing terminus at Euston at a depth of about 70 ft., is planned so that instead of the underground tracks ending in buffer stops according to the usual mode, they will form a loop at the terminus. The two single lines forming the loop have an end-on length of three-quarters of a mile, and are to be constructed in single-line tunnels. These two lines are estimated to cost £202,085, including £80,600 for the station. There will

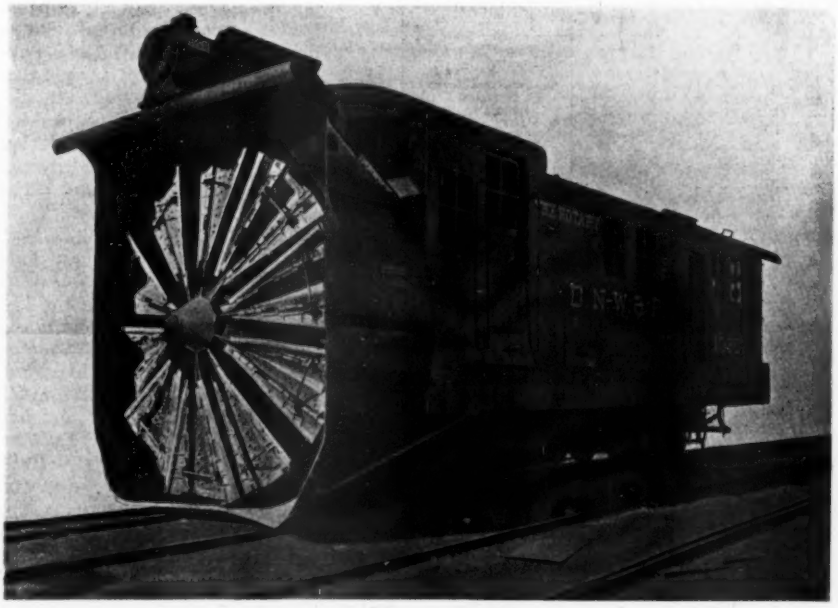


FIG. 2.—THE ROTARY STEAM PLOUGH.

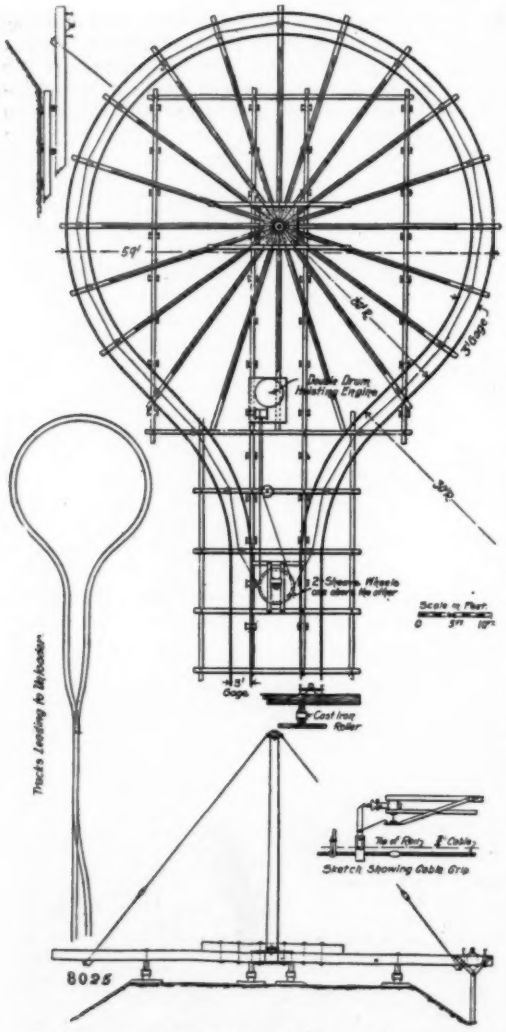


FIG. 3.—CONTINUOUS UNLOADER FOR BANK TIPPING. WESTERN PACIFIC RAILWAY.

also be a subway giving access from the Euston Road to the underground station, and this subway is expected to cost £20,800.

North of the loop the new underground railway will run in two parallel tubes, the up and down lines being in separate tunnels, for a distance of two miles as far as Loudoun Road. There the new line begins its rise to the surface, which is reached half a mile further on, the approach to the surface being on a gradient of 1 in 63. The estimated cost of this 2½ mile length of double line is £760,359, including £179,500 for underground stations at Chalk Farm and Loudoun Road. Shortly after leaving Euston the two tubes rise at an inclination of 1 in 90 towards Chalk Farm. From Chalk Farm to Loudoun Road they are on an up grade of 1 in 468.

This completes the underground portion of the new undertaking, which is thus estimated to cost £982,524. Where the line is in tube the station tunnels will have an internal diameter not exceeding 30 ft., and the tunnels between the stations will not (except where necessary for adjustment at curves) have an internal diameter exceeding 13 ft. 6 ins. This is a diameter 2 ft. 6 ins. less than the Great Northern & City, but some 1 ft. 10½ ins. greater than the diameter adopted by the Central London and by the tubes of the Underground Electric Railways Company. The question of diameter, it will be remembered, was much in evidence during the tube inquiries of 1901 and 1902.

From the point where the new lines rise to the surface they continue along the west side of the existing main line for a distance of 1 mile 2 furlongs 3·20 chains.

This widening is continued by Railway No. 4, which commences on the London Side of Willesden Junction, crosses over to the east side before reaching that station, then makes a detour so as to avoid interference with the numerous sidings at that important centre, and

again crosses the existing main line by a bridge at about half a mile south of Sudbury & Wembley Station. Railway No. 4 is 4 miles 3 furlongs 7.50 chains in length, and is estimated to cost £509,563.

Railway No. 4, is continued on the west side of the existing line from Sudbury & Wembley by widening No. 2 to Watford, a distance of 9 miles 2 furlongs 8 chains. In Watford itself there are two short double lines (Nos. 5 and 6) aggregating a length of 1 mile 1 furlong 1 chain.

The cost of the generating station, which it is proposed to erect on the company's own land near Wembley, is not, of course, included in any of the estimates here given.—*The Railway Gazette.*

Continuous Unloader for Embankments.

IN the construction of a length of the Western Pacific Railway in California, some deep embankments are being made by the use of a so-called "continuous unloader" which presents some interesting features. In general appearance it resembles a merry-go-round.

As shown in Fig. 3, the machine is constructed to take a circular track laid on a frame-work of heavy timbers, having an overhang of 12 feet in front and on the sides. At the rear, between the two tracks leading to and from the circular track, and resting on the frame timbers, is a donkey engine used to move the trucks, when the train is placed within reach of a cable, which extends round the machine. The cable is guided by sheave wheels around the circle between the rails, then on to the drum. The trucks are side tipping, and 3 ft. gauge. They are fastened to the cable by the simple device shown in the sketch. While the trucks are being pulled around by the cable the locomotive is making a switch from the delivery track to the receiving track, and is ready to couple on to the empties, the trucks being unloaded while going around the circular track by an ingenious device operated by two men. The cars can be unloaded at any point desired.

The portion of the bank on which the machine rests is carried five or six feet below formation level, in order to get the necessary base, and the machine is connected to the bank, which is up to grade, by two small bents. The space in rear of the first bent is filled in to grade by tipping behind the machine as it is moved forward, and the bents are pulled out and used again. The unloader is moved out on rollers, being drawn forward by a rope in blocks leading back to a gipsy on the engine. Five to six men on the unloader take care of all the cars that can be delivered to it.

The Railway and Engineering Review, to whom we are indebted for the foregoing particulars, states that this method has proved to be a most successful and economical way of making high embankments.

The appliance is easily and quickly taken apart and can be shipped from one piece of work to another without the loss of any piece of timber.

THE tendency to use increasingly high steam pressures that has formed so conspicuous a feature of locomotive practice during recent years,

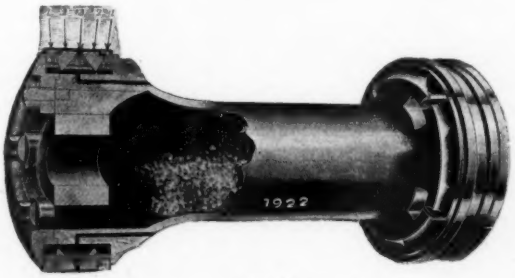


FIG. 4.

has naturally brought into favour the piston valve which, with its nearly perfect steam balance and minimum of friction, renders it perhaps more particularly suitable for high pressure work than ordinary slide valves fitted with pressure relief rings. There are certain disadvantages, however, attached to a form of piston valve in which solid packing rings are employed to effect a steam tight joint, as no relief would be possible for trapped water and damage would be almost a certain result. An ordinary slide valve can, on the contrary, be forced from its seat and so allow the water to escape. To overcome the difficulty the well known "Smith" valve was introduced, in which the packing rings were divided into three segments suitably guided, and capable of being forced out by steam admitted into the piston itself. When the outside pressure exceeded the inside pressure, the segments were free to fall inwards, thus allowing the water to escape.

Another form of piston valve possessing several features of interest has found favour in France and America and is now being tested on one of the railways in this country. Its details will be understood by the aid of Fig. 4, which shows a valve of the internal admission type.

The inner sides of the two snap rings, No. 1, are bevelled, the outer sides being straight to fit the straight walls of the valve spool. Against the bevel sides of these snap rings the rings No. 2 fit, the inner sides of which are bevelled to a greater degree of angle than the outer sides which fit the snap ring. Between these rings, No. 2, a double tapered snap ring No. 3 is placed, holding them apart and putting a slight grip on the snap rings in a lateral direction.

When steam is admitted to the valve chamber or the central portion of the valve it passes through openings in the spool to the space beneath all the rings and acts upon the central wedge ring direct, giving it a lead of the snap rings in action and forcing the intermediate rings against the sides of the snap rings, so that prevention of their excessive expansion is positive. The snap rings are thus expanded against the casing just enough to make steam-tight contact, and the central ring grips them there, and they are prevented from further expansion. This, we are informed, can be demonstrated by withdrawing the valve from the valve chamber while under steam until the first ring in the spool is entirely out of the cylinder, when no increase in the diameter of the snap ring can be observed. It can then be pushed right back into the cylinder again. The advantages would appear to be, therefore, that the packing rings expand, not only for the difference in contraction and expansion, but also for wear, and at the same time they are not so rigid as to damage a cylinder head before relieving the water from the cylinder, and yet they are adjusted to the diameter of the casing at all times, and are held there and allowed to get no larger during their work under pressure. The rings are so lapped that they are steam-tight from all directions, and by the level lap joint unbroken steam and exhaust lines are secured at the edge of the ring.

Six-coupled Goods Locomotive; L. & N. W. Railway.

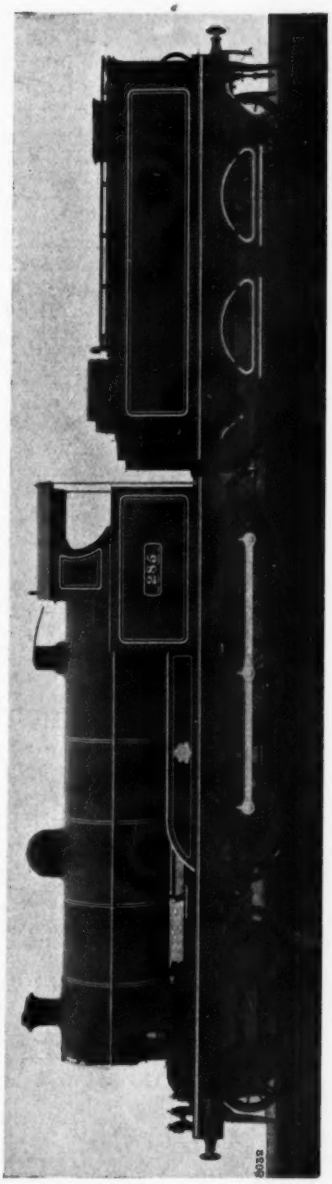
THE first of a new series of goods engines for working the heavy fast goods trains over the main lines of the London and North Western system, now under construction at the Crewe works of the company, has recently been placed in regular service. By the courtesy of Mr. G. Whale, chief mechanical engineer to the company, we are able to give the leading particulars and a view of the engine.

As will be seen, the new type, which closely follows the design of the "Experiment" class, has the 4-6-0 wheel arrangement and inside cylinders driving on to the front coupled axle. The steam admission is by Joy's valve

gear, the valves working on the top of the cylinders.

The following are the leading particulars :—

Cylinders	19 ins. diameter, by 26 ins. stroke
Boiler :—	
Barrel, mean diameter ...	5 ft. $0\frac{3}{4}$ in.
,, length	12 ft. 6 ins.
Distance between tube plates	12 ft. $10\frac{5}{8}$ ins.
Firebox, length outside ...	8 ft. 2 ins.
,, width outside ...	4 ft. 1 in.
Number of tubes	291
Diameter of tubes (outside)	$1\frac{7}{8}$ ins.
Boiler pressure	185 lbs. per sq. in.
Wheels :—	
Radial truck	3 ft. 3 ins. diameter
Coupled wheels	5 ft. $2\frac{1}{2}$ ins. diameter
Wheel base :—	
Radial truck	6 ft. 3 ins.
From centre of radial truck to centre of driving wheel	10 ft.
From centre of driving wheels to centre of intermediate wheel	6 ft. $9\frac{1}{2}$ ins.
From centre of intermediate to centre of trailing wheel	6 ft. $9\frac{1}{2}$ ins.
Total wheel base of engine	26 ft. $8\frac{1}{2}$ ins.
Height from rail level to centre of boiler	8 ft. 7 ins.
Heating surface :—	
Tubes	1840·5 sq. ft.
Firebox	144·3 ,,
Total ...	1984·8 ,,
Grate area	25 sq. ft.
Tender :—	
Water capacity	3,000 galls.
Coal capacity	6 tons
Wheel base	13 ft. 6 ins.
Weight of engine in working order :—	
On truck	18 tons 16 cwt.
On driving wheels	16 ,, 0 ,,
On intermediate wheels ...	14 ,, 15 ,,
On trailing wheels	13 ,, 9 ,,
Total ...	63 tons 0 cwt.
Total weight of engine and tender in working order	100 tons.
Total length of engine and tender over the buffers ...	57 ft. 5 ins.



4-6-0 EXPRESS GOODS LOCOMOTIVE. LONDON AND NORTH WESTERN RAILWAY.

NOTES AND COMMENTS.

Our Prize Contribution Scheme.

The inauguration of a series of prize competitions for contributions, full particulars of which appear on page 228, forms a new feature in connection with THE ENGINEERING REVIEW.

Most of our readers are probably aware of the success that has attended the publication of this journal from its commencement, eight years ago, and which might be held to be a justification in remaining contented with the features that have hitherto characterised it. The prize contribution scheme has been established in response to the suggestions received from many of our engineering friends with the object of encouraging those of our readers who are practical men to place their experience or practical ideas on public record.

We venture to believe that the new feature will be very generally appreciated, and calculated to amplify the support already accorded to the REVIEW.

The Next Engineering Exhibition at Olympia.

The Engineering and Machinery Exhibition that is to be held in London in the autumn of the present year is the outcome of the exhibition held at Olympia in 1906, which latter aroused widespread interest in engineering circles, not only by reason of the fact that it was the first of its kind to be held in the metropolis for many years, but by its intrinsic importance.

Judging by the list of Patrons and advisory committee that has been arranged, comprising the names of the leading men in most branches of the industry and the representatives of many important foreign interests, and also by the fact that a large area has already been booked up, the forthcoming show bids fair to eclipse its predecessor. Moreover, the enlargement of the scope of the exhibition, together with the additional features proposed, render the attendance of those specially interested practically assured.

The educational aspect of the exhibition will again receive the greatest possible attention, even greater facilities than last year being afforded to students to visit under the guidance of experts, while specially reduced rates will be charged to parties of workmen. The loan section is likely to be of much larger proportions than last year, as there are no other large exhibitions of engineering interest on at the same time. The Colonial Conference to be held in this country this year is sure to attract visitors associated with mining and general engineering, and the management are taking special steps to have on show all the latest improvements in connection with gold mining, quartz crushing, and other ming work.

If anything were wanting to justify the confidence thus early shown by those who have already booked space, we have the testimony of numerous exhibitors as to the satisfactory character of the business results accruing from the last show to bear witness.

One fact which is worthy of note is that at recent exhibitions of an important character, Continental manufacturers have generally been well represented. This was particularly noticeable at the last Olympia show, and although we do not for a moment suggest that our own manufacturers are lacking in appreciation of the undoubted value such exhibitions possess as a means of publicity and fostering trade, we hope that no lack of enterprise will prevent them doing justice to themselves and the British industry generally by securing adequate representation and bringing their specialities well to the front.

Recent Gas Engine Developments.

100 B.H.-P. "Ruston" Suction Gas Plant.

The accompanying illustrations are those of a suction gas plant capable of developing 100 brake horse-power, recently built by Messrs. Ruston, Proctor & Co., Lincoln, and which has several interesting and original features.

The generator is made up of cast iron, and consists of the following parts, viz., hopper, fuel chamber, vapour chamber or vapouriser, casing and ashbox. The hopper is used for charging the generator with fuel, and is provided with a cover at the top and a valve at the bottom. The fuel chamber is for the storage of fuel in the generator, and is capable of accommodating sufficient anthracite to last from three to four hours, or gas coke to last from two to three hours, according to the load on the engine.

The vaporiser is of the internal type, and and is used for forming most of the vapour for the generator. The chamber contains water, which is heated by the hot gas circulating round it, and also by radiation from the incandescent fuel below.

Air is drawn through the air inlet, and passes over the surface of the hot water, where it mixes with the vapour there formed. The mixture of air and vapour then passes down the vapour-pipe to the ash-box, and thence through the body of incandescent fuel, where it is decomposed and formed into a fixed gas. The water in the chamber is kept to a certain level by means of a supply and overflow pipe, the overflow water from the chamber being carried to the ash-box, where it is used for forming a further supply of vapour.

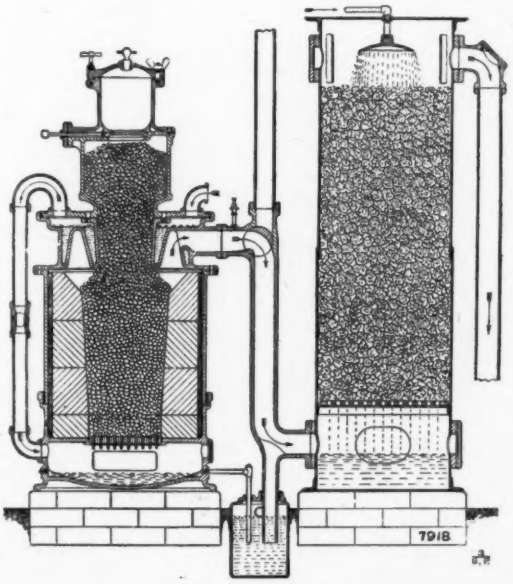
The ash-box is dished at the bottom, forming a water basin, being supplied with surplus water from the vaporiser. This helps to keep up the quality of the gas when cleaning the firebars, as the hot ashes fall into the water and generate the necessary steam. This is a great advantage, as long runs can be made without having to stop to clean the generator.

The gas passes, by way of the connecting pipe, to a very high steel scrubber, almost filled with coke, where it is cleaned and cooled, and from there it enters a large steel expansion chamber placed close to the engine.

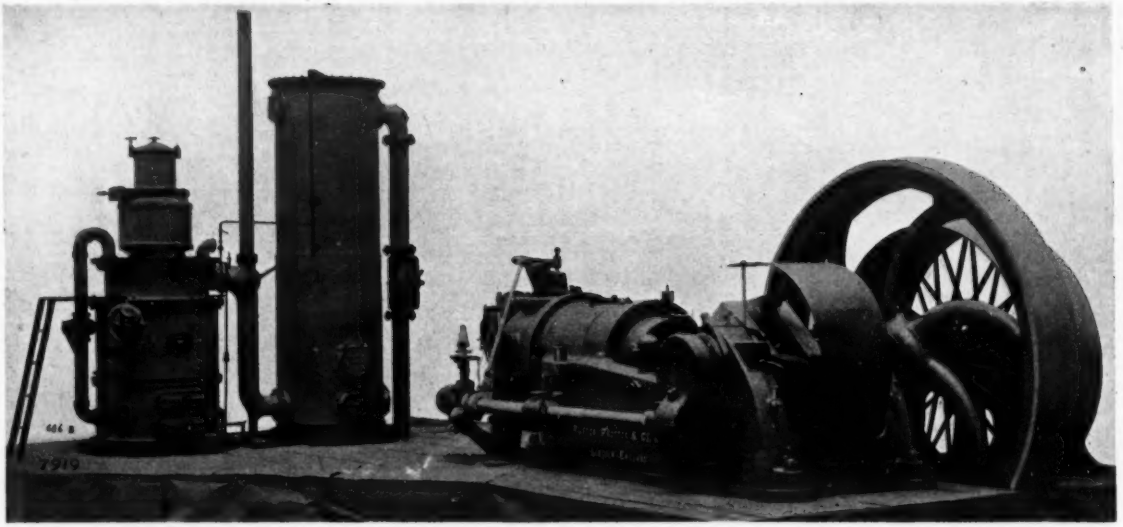
A three-way cock is fixed in the connecting pipe, and by means of this the generator is fixed in communication with either the atmosphere or scrubber, but never to both at the same time. The liability of explosive mixtures being made is thus avoided; moreover, the number of joints is reduced to a minimum, thus tending to eliminate the possibility of leakage.

The plant is very compact, taking up very little space, and can be arranged in numerous different positions. It is very simple, requires little attention, and can be cleaned out readily.

A fan, worked by hand, is used for starting up, and good gas may be obtained within a quarter of an hour of lighting the fire.



DETAILS OF THE "RUSTON" GAS PRODUCER.



100 B.H.P. "RUSTON" SUCTION GAS PRODUCER SET.

Anthracite, gas coke, or charcoal can be used as fuel, but a tar separator is supplied when coke is used. This is a very simple and effective thing, and is placed between the scrubber and the expansion chamber.

The consumption with anthracite is ¾ lb. per b.h.-p. per hour, and 1 lb. with coke. The total water required is also very low, and does not exceed 1½ gallons per b.h.-p. hour.

With regard to the engine, it may be mentioned that the cylinder and bed plate are cast in one piece, and the back end separate, the latter being bolted to the cylinder.

A renewable liner is fitted in the back end of the cylinder, being held by bolts on the outside of the cylinder in such a way as to leave the liner free to expand in a forward direction. The gas valve box also consists of a loose casting, and is bolted to the cylinder back end. High compression is used, the tendency to pre-ignition being eliminated by water-cooling the piston and the provision of a special water-cooled chamber in the back end. The exhaust valve is also water-cooled. Ignition is by a low-tension magneto, and is adjustable between wide limits while the engine is running.

Improved "Akroyd" Oil Engine.

Mr. Akroyd Stuart, M.I.Mech.E., well known as the inventor of the original "Hornsby-Akroyd" engine, has recently introduced an improvement which can be applied to existing oil

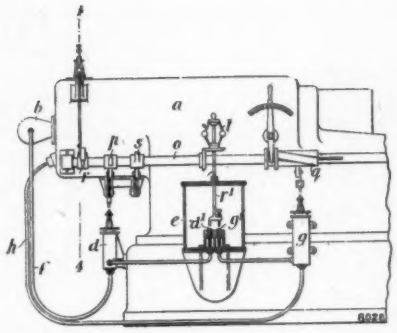


FIG. 1.

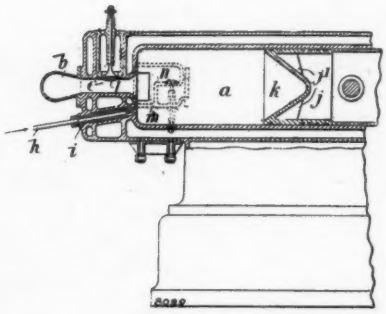


FIG. 2.

engines of that type with the result that an increased efficiency is obtained. It is generally known that the special features of this engine are the vaporiser whereby automatic ignition is effected, no firing valve, hot tube, or electric ignition apparatus being required; and further, that the engine has a large cylinder capacity for the power developed, for the reason that a quantity of air considerably in excess of that necessary for the proper combustion of the hydro-carbon vapour produced in the vaporiser, is drawn into the cylinder.

By the improved method this air is utilised in a way that will be understood with the aid of the accompanying drawings, of which Fig. 1 is a sectional elevation of an engine operating on the new method, Fig. 2, a longitudinal section, Fig. 3, a diagram taken from an ordinary "Hornsby-Akroyd" oil engine, and Fig. 4, a diagram taken from the same engine, re-adjusted to the improved "Akroyd" cycle. From Figs. 3 and 4 it will be seen how more power is obtained with cylinders of equal dimensions, and engines running at the same speed.

The working cycle of the improved engine is as follows:—

In the operation of the engine the liquid hydrocarbon is injected into the cylinder through the passage *i* when the piston is at or near the end of the exhaust stroke by means of the pump *g*. During the next or suction stroke, air, which enters through the valve *l*, carries the cylinder charge of vapour forward in the cylinder, so that either pure air or air only slightly diluted with hydrocarbon vapour remains at the back of the cylinder; at the same time a charge of liquid hydrocarbon is injected into the vaporiser *b* and vaporised therein. There are thus two combustible charges, one in the vaporiser and the other in the cylinder, separated by a layer of air. During the next in-stroke the charge in the cylinder and vaporiser is compressed and the heat augmented to such an extent that when the piston reaches its innermost position a simultaneous or successive automatic

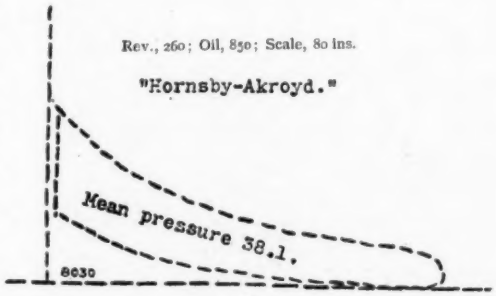


FIG. 3.

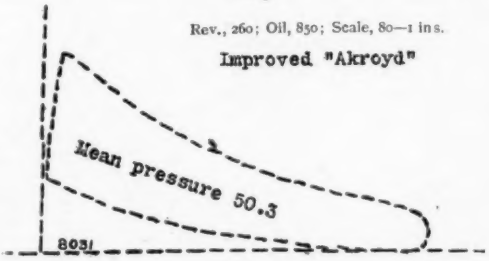
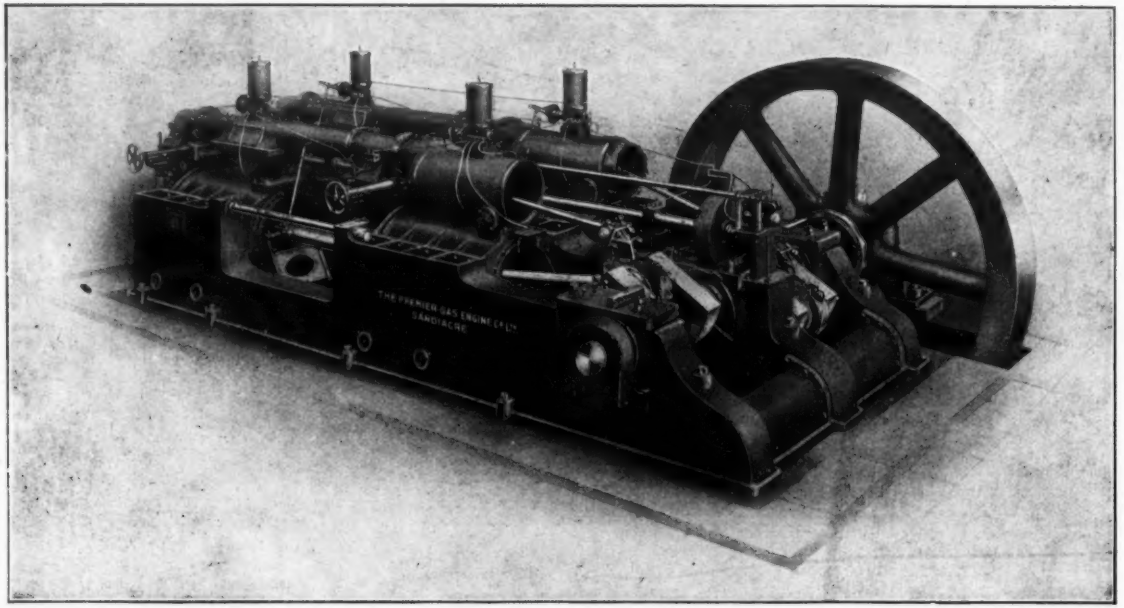


FIG. 4.



1,200 H.-P. "PREMIER" GAS ENGINE.

ignition takes place in the cylinder and in the vaporiser. The products of combustion are discharged through the exhaust valve *n*, in the usual manner during the fourth stroke of the cycle when the foregoing operations are repeated. When it is desired to run the engine light or with light loads the pump *g*, supplying the cylinder charge, is put out of action, when the engine will continue to operate with a vaporiser charge only, as in the working of the original engine.

It is sometimes found advisable to vary the times of introducing the two charges of fuel, and this can be effected by varying the position of the cam *q* upon the shaft *o*; also instead of introducing the hydrocarbon directly into the cylinder it may be introduced into the air passages so as to enter with the air during the first part of the induction stroke.

The inventor claims to get 20 to 25 per cent. more power out of engines of equal dimensions than was possible with the older cycle.

1,200 h.-p. "Premier" Gas Engine.

The illustration opposite is that of a 1,200 h.-p. four-cylinder gas engine, recently completed by the Premier Gas Engine Company, Ltd., Sandiacre, to whom we are indebted for the privilege of being allowed to inspect the engine while on the testing bed.

The engine, which has been constructed for direct coupling to a continuous-current generator, is designed for working with producer gas, and to develop 1,200 h.-p. when running at a speed of 150 revolutions per minute. On test, however, the engine proved itself capable of developing a considerable overload capacity, the mean pressure shown by the cards taken working out at 110-120 lbs. per sq. in., whereas when developing 1,200 h.-p. the mean pressure of the cards was from 85-90 lbs.

The engine, as will be seen, has four cylinders, and virtually consists of two of the "Premier" standard type engine, arranged side by side. The cylinders are arranged in tandem pairs, each working on the four-stroke cycle on cranks, set at 180 degs. As each cylinder gives an alternate impulse, thus producing two explosions at each revolution, a very even turning moment is produced. The framing consists of three box girders running the whole length of the engine, the cylinders being placed between them, tying them together. The girders are further tied at the crank end by a strong box section cross-piece. The pistons of each of the two pairs of cylinders are connected together by hollow steel piston rods passing through stuffing boxes in the cylinder heads of the front cylinders, and conveying the cooling water for the pistons by means of the hole through their centres, the supply being through swinging frames attached to the rod. Both motor pistons and exhaust valves are water-jacketted.

The chief feature of the engine, as it is indeed of all the "Premier" engines, is the method of positive scavenging by which, in engines of large power, the company have been able to overcome many of the difficulties incident thereto.

The products of combustion which, in the ordinary engine, are allowed to remain in the clearance space behind the piston, are swept out by a charge of air forced through the clearance space by air pumps placed above the front cylinders, and driven from the main connecting rods through a bracket. The air is supplied at a pressure of about 3 lbs. per sq. in., the admission being effected just before the end of the fourth or exhaust stroke. On the outstroke the piston and pump move forward together, and the air, entering through an automatic inlet valve, divides up, one portion entering the air-pump and the other passing to the motor cylinder.

An air silencer, fitted with an arrangement for filtering the air drawn into the engine, is provided. It will thus be seen that not only is the combustion space filled with pure and cool air instead of the products of combustion, but also that the passage of cool air over the valves and internal surfaces which come in direct contact with the flame, helps to cool these surfaces, and thus tends to prevent overheating. As the air is cool before compression it is possible to work with a high compression—in this case 140 lbs.—without experiencing trouble in the way of premature ignition.

The admission, exhaust and gas valves are arranged on the cylinder head, working horizontally in long gun-metal bushes. The gas valves are grid slides arranged to give a large passage, and to permit a thorough mixing of the air and gas. The main admission and exhaust valves are operated by levers made from mild steel forgings, and receiving motion from grooved cams on a horizontal shaft placed above the centre girder, and driven at half the speed of the crankshaft by screw-gearing. Both the opening and closing are thus positive.

The gas valves are operated by the usual form of cam, by means of a rocking lever having a notched plate engaging with a chisel blade, both made of hardened tool steel, and blade being controlled by the governor. The latter is of the high speed centrifugal type, and is driven by a screw-gear wheel from the crankshaft. The engine will fire every time down to one-third load.

All valves are readily accessible for examination by means of a door, as is also the water space of the cylinder.

Another device to facilitate examination of the piston and piston rings, consists of a shoe forming part of the liner of the forward cylinders.

On withdrawing the pistons clear of the cylinder, the shoe serves as a support for the front pair, those behind being held in position by the piston rod.

Each cylinder is fitted with a duplicate electric ignition, the arrangement being such that one pair of firing points can be withdrawn for cleaning while the other pair is at work.

The fly-wheel, which is cast in one piece, is 12 ft. diameter and weighs about 16 tons. Starting is effected by means of a self-starter,

consisting of valves for automatically admitting at the right period of the cycle compressed air, furnished by a small compressor, to two of the cylinders. The operation of starting is effected with ease and with very little more trouble than in the case of a steam engine.

The power consumed by the air pumps is not high so that the mechanical efficiency works out at 87 per cent.

Books Received.

O'Gorman's Motor Pocket Book. 2nd edition, 301 illustrations. (London: Archibald Constable & Co., Ltd.) 1907. Price, 7*s.* 6*d.* net.

The Local Government Annual and Official Directory, 1907. Edited by S. EDGECUMBE ROGERS. (London: "The Local Government Journal" Office, 27a, Farringdon Street, E.C.) Price, 1*s.* 6*d.*

"Napier" Instruction Book. (London: S. F. Edge, Ltd., 14, New Burlington Street, W.) Price, 1*s.*

Electric Ignition for Motor Vehicles. By W. HIBBERT, A.M.I.E.E. (London: Whittaker & Co., 2, White Hart Street, E.C.) Price, 1*s.* 6*d.* net.

Notes on Construction in Mild Steel. By HENRY FIDLER, M. Inst. C.E. (London: Longmans, Green & Co., 39 Paternoster Row, E.C.) Price, 16*s.* net.

ELECTRICAL ENGINEERING NOTES.

By ANDREW STEWART, A.M.I.E.E.

New Electric Lamps.

It has been said, with a fair amount of truth, that the gas lighting industry fired the last shot in their locker when the "Welsbach" mantle was brought out, for it can go little, if any further in point of efficiency, while the incandescent electric lamp, which has stood still for about twenty-five years, has startled its enemies, and embarrassed its friends, by the profusion of new high efficiency lamps, mostly of rare metals, but including the ordinary carbon filament metallised.

The subject has attracted such wide-spread attention that one feels almost overwhelmed amid the babel of rival claims and prophecies, for each new type of lamp has its following of technical men with test curves, and prophecies of long and vigorous life for the promising youngster.

We have before us papers read to the American Institution of Electrical Engineers, the British Institution of Electrical Engineers, both in London and in Birmingham, and much supplementary matter, which indicates only one thing, viz., that in the opinion of many, the carbon filament lamp will shortly, to use a sporting term, appear at the foot of the list marked "also ran." Which lamp will be first is of course, another matter, but no one appears to have any doubt about the lamp that is to occupy last place.

There are the following competitors for public favour, viz., "Tantalum," "Osmium," "Osram," "Tungsten," "Helion," "Zircon-Wolfram," and the metallised carbon filament. Each has its own special disadvantages, nearly all share the common disadvantage of being dear, and they cannot be made for small candle-powers on 200 volt circuits. The latter seems more likely to be overcome in some lamps than in others.

The disadvantage of being unable to use the lamp on a 200 volt circuit is more serious than would at first sight appear, for though two may be used in series on 200 volts, yet it is not always convenient, and gives more light than is necessary or desirable. It is a somewhat striking commentary on engineering progress that distribution problems practically forced electric supply authorities to adopt 200 volts as the pressure at consumers' terminals, and that this voltage should now be the only barrier to the extensive adoption of the new high-efficiency lamps, thus retarding the greatest forward movement in the history of electric illumination; indeed, the rapid adoption of such high efficiency lamps would be almost revolutionary. The present carbon filament glow lamp takes $3\frac{1}{2}$ to $4\frac{1}{2}$ watts per candle-power, the new lamps 1 to $1\frac{1}{4}$ watts per candle-power, so that for the same amount of illumination one may only use about one-fourth the amount of energy.

A few high-efficiency carbon filament lamps are sold under the names of "Witelite," "Brightlite," and other kinds of "lite," but these do not come within the category of new lamps, as they are merely ordinary carbon filaments in a somewhat larger globe, run above their normal voltage, and giving a candle-power for 2 or $2\frac{1}{2}$ watts, with a life of only 400 to 600 hours, so that they have a short life, but a bright one. This is no new feature, for German lamp makers have long made ordinary glow lamps like this, thus getting a spurious reputation for producing efficient lamps.

Of the various metallic filament lamps, "Tantalum" is best known; we dealt with this lamp some considerable time ago,* and there is little to add except that experience

* THE ENGINEERING REVIEW, August, 1905.

has proved that it is sometimes very unsatisfactory on alternating current circuits. "Osmium" is expensive, because of the rarity of the metal, and lamps made of it can only be used in a vertical position, because when hot, it is so plastic that it sags seriously. This metal is very suitable, as it has a melting point of some 2,200° C. The "Osram" lamp probably has as a basis "Osmium," though the fact that the metal is crystalline and very hard, and cannot be drawn into wire, but must be mixed with a suitable substance, and in the form of paste, squirted through a die just as the ordinary carbon filament, renders possible many combinations having "Osmium" as a basis.

"Tungsten" is better known to our readers, as it forms a very important ingredient in self-hardening, high-speed tool steel. It is difficult to make it into filaments owing to its brittle nature, and it is therefore used for metallised carbon filaments, a process which is comparatively easy owing to its affinity for carbon, the carbon filament being heated in an atmosphere of tungsten chloride and hydrogen. The "Tungsten" filament lamp is made by producing colloidal tungsten by the electric arc; this may be squirted through a die, the resultant filament is dried, and an electric current is passed through it when it assumes a crystalline form.

The "Helion" lamp is distinct from its competitors, inasmuch as it is the only lamp with a non-metallic filament. Little accurate information concerning this lamp is available, but it appears that its critical temperature is somewhat lower than the others, and as the efficiency of a luminous filament is governed entirely by its temperature, it would indicate rather limited possibilities.

The "Zircon-Wolfram" (tungsten) lamp is made commercially for 16 candle-power 100 volts, and 32 candle-power 200 volts. In this respect it is ahead of most of its competitors, for no metallic filament lamp has hitherto been made to give 32 candle-power on a 200-volt circuit. A compound lamp of this type opens up wide possibilities, for while zircon has a comparatively speaking low melting point; this difficulty is to some extent overcome by alloying it with tungsten.

The great difficulty with the new lamps is the comparatively low specific resistance of the material employed. This necessitates a long, thin filament, and even when, as is usual, drawn to a thickness of $\frac{1}{800}$ inch, about the thickness of a human hair, it does not have a resistance great enough to keep the length of the filament reasonably short; for instance, the length of the filament in a "Tantalum" lamp is over 25 ins. for 100 volts. As it is made as thin as practicable, it is necessary to double this for a 200-volt lamp, which gives a length that is impracticable even if the candle-power, viz. 50 at the higher voltage, were suitable for most classes of indoor lighting.

The foregoing indicates the chief materials which are likely to be found in the glow lamp of the early future. In some cases, such as "Tantalum," "Osmium," "Osram" and "Zircon-Wolfram," 100-volt lamps are a commercial article, but no great advance can be expected until the advent of a 220-volt lamp. It is interesting to note that the earliest incandescent electric lamps were made with platinum filaments, which were abandoned in favour of carbon. The former melts at 1,710° C.; the latter is infusible, but filaments made from it fail due to disintegration or volatilisation at high temperatures. The new lamps mark a reversion to metallic filaments, but the fusing temperatures vary between 2,000 and 3,200° C.

Electric Winding Equipments.

Recent developments in electric winding indicate that there is a growing tendency to instal electric winding apparatus where electric supply can be obtained at a reasonable price from an outside supply authority. In such cases it is usual to instal some arrangement for taking up the fluctuations in the load which, if uncared for, would prove a source of serious trouble, not only to other power users on adjacent circuits, but even on the mine itself, as lighting would be practically impossible, owing to the variations in the load causing violent fluctuations in the voltage.

There are a few cases where it is hardly necessary to take precautions, for instance, where there is a special power generator or generators, supply pit-head motors, and pumping, coal cutting, and haulage motors underground, lighting being supplied from a separate dynamo. There are several installations of this kind to be met with, and winding, if the generators are large enough, can be effectively done with a large motor geared to the winding drum. Starting and speed control is effected by a resistance in series with the motor, or if a polyphase machine, in series with the rotor

winding, a liquid resistance being often used because of its low cost, and comparative high heat capacity.

The depth indicator may be arranged so that it automatically forces the controller to the "off" position and applies the brakes when the cage approaches the bank.

It has been found that, where large powers have to be dealt with, gearing between the motor and the winding drum may be eliminated with advantage. Polyphase motors operated on 25-period-circuits lend themselves specially to this kind of work, for while higher periodicities are quite practicable, slow-speed induction motors for 50 cycles become more expensive, have somewhat lower efficiencies, and a lower power factor than the 25-cycle machines. On the other hand, transforming apparatus costs more, and the small motor user is handicapped, inasmuch as his 25-cycle machines are more limited in speed, and the total cost of an installation of 25-cycle machines, if there are many small motors, is greater than would be the case for 40, 50 or 60 cycles.

Most systems of equalising the load on the generating station when electric winding is employed, consist in using a fly-wheel in some form or other, the stored up energy in which becomes available during the period of acceleration of the cage. Some early plants had an engine and generator supplying the winding engine, and a few large motors; this generating plant had a very heavy fly-wheel, which, as the load came on, slowed down and gave up some of its store of kinetic energy. Another consists of an electric motor with a very heavy fly-wheel, running alone on the circuit. Under normal conditions this machine takes power enough to overcome the windage of the fly-wheel, and armature and bearing friction. As soon as any sudden demand takes place, such as the starting of the winding engine, the voltage of the circuit falls, due to the heavy overload, but the inertia of the fly-wheel maintains the speed of the motor with but a slight fall from the normal, and as the back E.M.F. of the motor is temporarily above that of the line, it becomes a generator, giving up to the line the stored up energy in the fly-wheel. As soon as the load goes off, the functions of the machine again become reversed, and the motor accelerates the fly-wheel up to the normal speed, ready for the next demand.

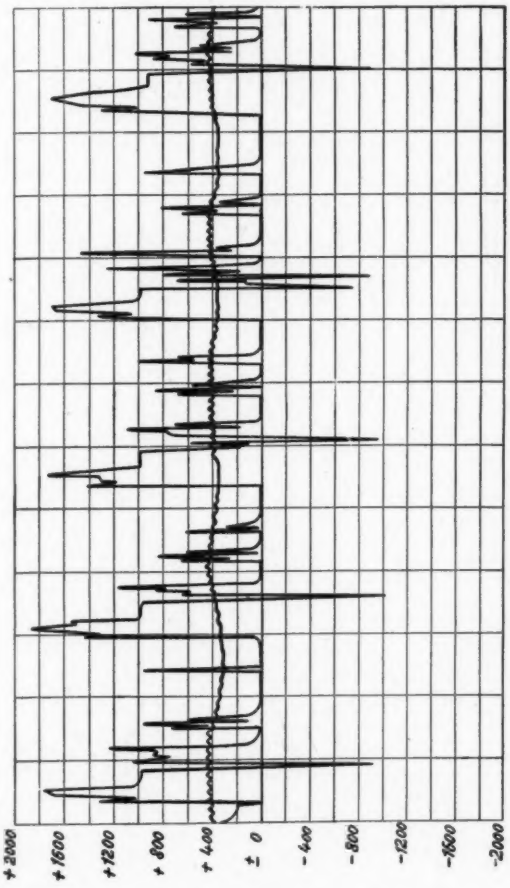


FIG. 1.—LOAD ON ELECTRIC WINDING ENGINE, AND LOAD ON GENERATOR WHEN SUPPLIED THROUGH FLY-WHEEL CONVERTER.

Other systems have been evolved from this, one, a reversible booster in series with the line supplying the winding engine, its

E.M.F. raising the line voltage in proportion to the speed, the set being separately excited.

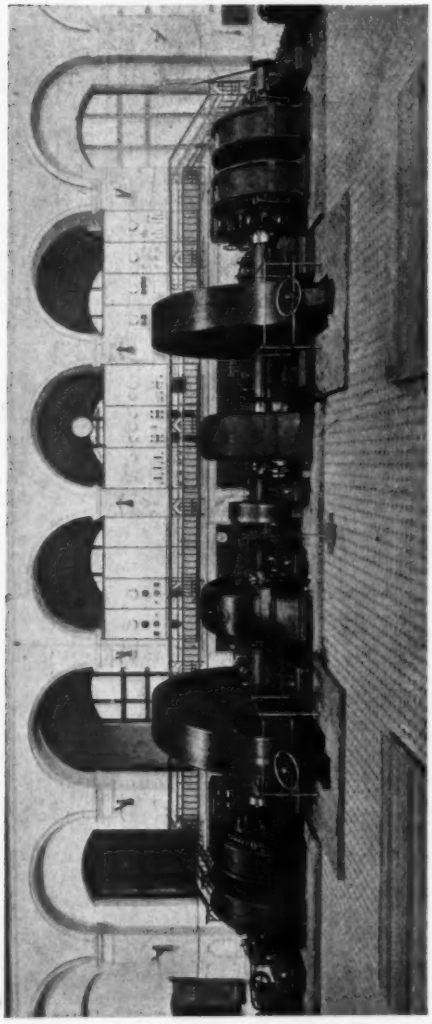


FIG. 2.—THE "SIEMENS-ILGNER" FLYWHEEL CONVERTER AT THE MATHIAS STINNES MINE, NEAR ESSEN.

Some idea of the violence of the fluctuations will be obtained from Fig. 1, which shows the load on the winding engine when starting and during the period of acclera-tion, also the period of retardation when the cage is brought to rest quickly at the end of the wind. The slightly irregular wavy line is the load smoothed out as it comes on the source of supply, after passing through the converter.

It is obvious that a steam winding engine feels all the violent fluctuations shown by the diagram, consequently it is impossible to utilise the steam economically; indeed, the superior economy of the electric winder has never been disputed, but, as has been pointed out in our columns,* it is asserted that the saving does not, under certain circumstances, pay interest on the capital sunk in the more expensive plant.

An example of a simple winding plant, without an equaliser, is the Grand Hornu Mine, Belgium. Here a three-phase motor drives the winding engine, which runs at a maximum speed of forty-two revolutions per minute. The maximum winding speed is slightly over 3,000 ft. per minute, the shaft being 546 fathoms deep and raising 85 tons of coal per hour. A flat rope wound on a narrow bobbin or winding drum, each coil coming on the top of the preceding one, is used. The initial diameter being 8 ft., and the final diameter, when all the rope is wound on, is 24½ ft.

One of the most notable and up-to-date mining equipments is that of the Mathias Stinnes Mine at Carnap, near Essen. In this plant the now well known "Ilgner" system of equalising the load on the source of supply is adopted.

The generating station, which is in this case a public supply, the Rhenanian Westphalian Electricity Works, supplies threephase current for all purposes, and delivers part to the motor converters.

These motor converters consist of two polyphase induction motors shown in the centre of Fig. 2, which illustrates two motor converters, one to the right and another to the left, the sets being coupled together if necessary by the coupling seen in the centre.

The induction motors drive the fly-wheel and the two direct current dynamos seen at either end of the set. These fly-wheels are solid steel castings, weighing about 40 tons, running at a peripheral velocity of about 15,000 ft. per minute, which is considered the upper limit for these wheels. The direct current generators at each end supply the winding engines, one of which is shown

* See review of the relative merits of steam and electric winding, THE ENGINEERING REVIEW, May, 1906.

(Fig. 3), from which it will be apparent that the "Koepe" pulley is placed between two direct current motors, which drive it.

Fig. 3 shows the winding engine very clearly, the horizontal cylinder, seen on the floor, operates the brake, which will be seen

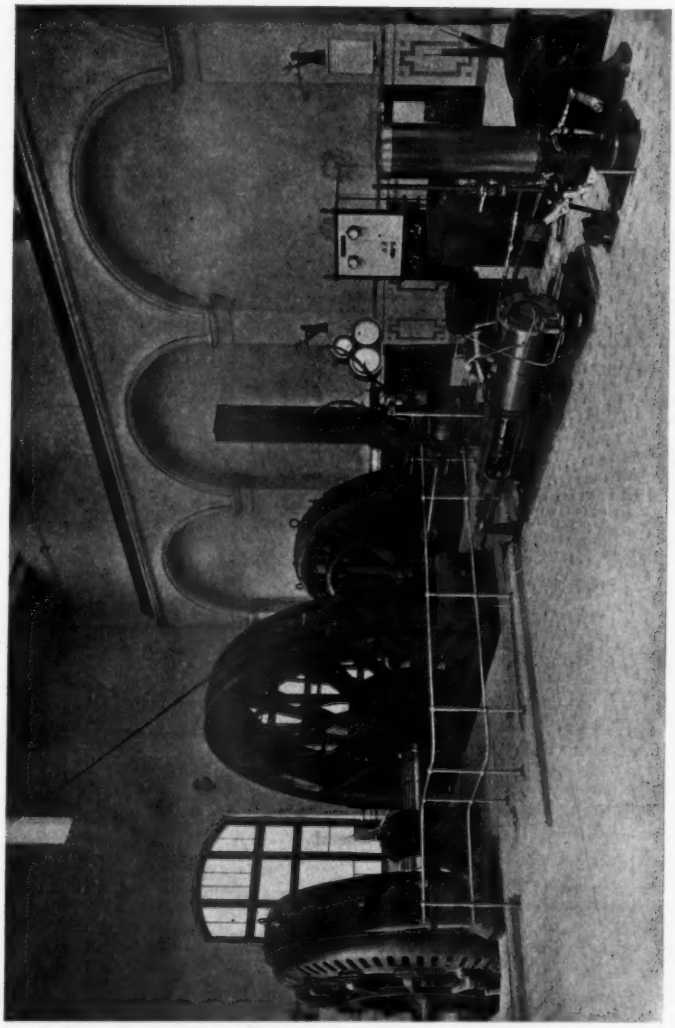


FIG. 3.—ONE OF THE WINDING ENGINES, MATHIAS STINNES MINE, NEAR ESSEN.

The shaft is 545 yds. deep, and a load (useful) of 4·8 tons is raised at each wind with a maximum speed of 2,450 ft. per minute, the output being 100 tons per hour.

on the pulley; the vertical cylinder on the right, close to the controlling levers, is for the purpose of sustaining the emergency brake.

The foregoing installation is characteristic of many which have been erected in Germany, Belgium, and England within the last year, and no doubt there will be a considerable increase in the number of such installations, especially if the rapid acceleration, which is possible with these equipments, enables the mine to deal with a much larger output per day from one shaft, thus keeping the capital sunk in the equipment for each ton of coal handled down to a minimum, combined with the fact that cheap electrical energy may be purchased from an outside source, rendering unnecessary the capital cost of a generating station. All this combines to induce the colliery owner to instal an electrical plant for winding as well as for all the other purposes for which electricity is now recognised as the only satisfactory means of transmission and distribution.

Petrol-Electric Omnibuses.

We have from time to time* recorded the developments which have taken place in this branch of engineering activity, and the merits of the latest development were ably expounded by Messrs. Hart and Durtnall, before the Society of Omnibus Engineers a short time ago.

As some of our readers are aware, it is not uncommon for half the power developed by the engine of a motor omnibus to be wasted before it reaches the tyres of the driving wheels. The bulk of this loss takes place in the gear-box, and so successful are the engine's efforts to wear down the gear, that an average life of six months is about the usual experience of motor omnibus owners for this part of their vehicles.

The efforts which have been made to get rid of the gear-box by substituting an electric system of transmission are natural, considering the success of the electro-motor in other branches of traction work, and the authors of the latest system had an easy task in reviewing the petrol-electric combinations which had gone before their own.

The new system differs from several previous combinations only inasmuch as a three-phase generator is coupled to the engine, and this supplies an induction motor of the short circuited rotor type, with polyphase current, the power from which is transmitted, viâ the cardan shaft, to the differential on the live back axle.

Fig. 4 shows the general arrangement: *A* being the engine, *B* the fan, *C* the generator, *E* the motor, *D* a clutch, the function of which is to obtain a direct mechanical drive between engine and back axle at full speed, and thereby avoid the double conversion of energy. This clutch is an electromagnetic device which can be operated at the highest speed by switching it in series with the exciting dynamo. *F* is the cardan shaft and *G* the differential gear.

Speed control at the slower speeds is obtained by re-grouping the stator (fixed) winding of the induction motor *E*, so that it has more poles, and its normal speed reduced. As acceleration takes place, the number of stator poles are halved by a simple re-grouping process, effected by merely moving the controller-handle further round, and when the maximum speed has been attained, the electromagnetic clutch is connected to the exciter dynamo which gives a direct drive from the engine to the rear axle.

The starting may be improved by temporarily raising the voltage of the main generator *c*. As the torque of an induction motor is proportional to the square of the

* November, 1905, and August, 1906.

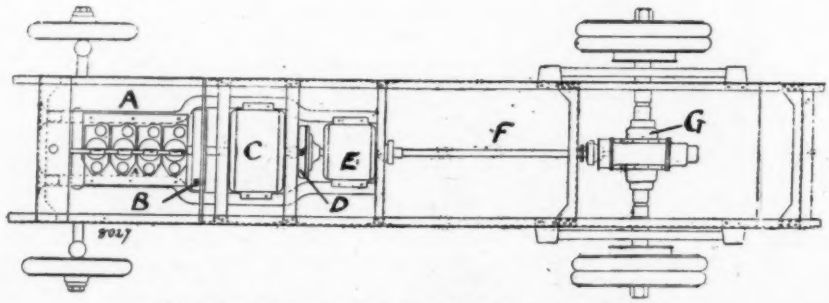


FIG. 4.—PLAN OF "HART-DURTNALL" PETROL ELECTRIC OMNIBUS CHASSIS.

impressed voltage, this expedient gives good results. Another advantage of the system is the fact that the induction motor when driven above synchronism, become a generator and acts as a brake. Synchronism would correspond to a speed of twelve miles per hour, so that a small increase over this would serve to make the motor a powerful brake, but unless substantial resistances are provided to absorb the load any reliance on this might lead to disaster; so also would any accidental stoppage of the engine, for the induction above synchronous speed only acts as a generator when there is a separately excited generator working in parallel to provide the magnetising current. There is no evidence in the paper that the authors are fully acquainted with the properties of the induction motor under these abnormal conditions, and it is doubtful if any reliance could in practice be placed on such a breaking action, as it depends on the engine working all the time, the integrity of the exciting circuit, and the capacity of the resistances to absorb the power that the motor generates over perhaps an extended period, such as descending a long hill.

A temporary interruption in the circuit of the two latter would probably prove disastrous if the driver did not have his wits about him, and most accidents have generally been more disastrous than they need have been, owing to the secondary effect of the failure of the man in charge to realise the possible alternatives, and act quickly.

The authors' fear of rubbing contacts has led them to adopt the induction motor with simple short circuited rotor, instead of a machine with wound rotor; the latter is much more suitable for a variable speed, and, owing to the higher torque per ampere input, might have enabled them to use a generator of less generous proportions, thus reducing the weight and cost.

During Mr. Durtnall's reply to the discussion, he claimed that they were now engaged on the application of electric transmission to marine propulsion, probably for the first time. The subject has received some attention abroad, and in our issue of June, 1905, we described a large cargo vessel having internal combustion engines and electric transmission.

Internal-Combustion Engines for Marine Purposes.

At a recent meeting of the Institution of Civil Engineers an interesting paper was read on this subject by Mr. J. T. Milton, M.Inst.C.E., of which the following is an abstract:—

The special conditions required for a successful marine engine are:—

(*a*) The engine must be reversible;

(*b*) It must be capable of being quickly stopped, and of being quickly started, either ahead or astern;

(*c*) It must be capable of being promptly speeded to any desired point between full speed and dead slow, which latter speed ought not to be greater than one-quarter of the full speed;

(*d*) It must be capable of working well, not only in smooth water, but in heavy weather in a seaway in which the varying immersion of the propeller causes rapidly-changing conditions of resistance.

In large engines these conditions prohibit the use of movable-bladed propellers, clutches, and toothed gearing, and also of a fly-wheel, and necessitate the use of a reversing engine with a direct drive on to a fixed propeller, and they require also a fairly equable turning-moment at all working-speeds.

In marine engines the revolutions are practically proportional to the speed of the ship, and as the vessel's resistance increases much more rapidly than the speed, it follows that for a reduction of speed of revolution the mean effective pressure must be reduced much more than in proportion to the revolutions.

This is a much more difficult problem in marine engines, where no fly-wheel is practicable, than on land, where the use of a heavy fly-wheel permits the suppression of alternate fuel-charges.

The question of the turning-moment of the engine receives consideration. With the four-stroke cycle, where one single-acting cylinder only is employed, the fluctuation of moment varies from 7·7 times the mean moment in a forward direction to 1·5 times the mean moment in the reverse way. With two such cylinders, or with one double-acting cylinder, the motion is better, but is still unsuitable, and the minimum number of cylinders which will always give a positive turning-moment is four single-acting or two double-acting.

Diagrams are shown of the turning-moments resulting from a vertical two-cylinder tandem engine with one crank; also of three such engines working on one crank-shaft with the cranks at equal angles, and of four such engines with cranks at equal angles, and at intermediate positions, and the inference is drawn that the arrangement with three cranks is, on the whole, preferable for marine work. Such an engine, however, working on the four-stroke cycle will not give the range of low speed necessary for marine work.

The question of carrying out the compression and expansion in separate cylinders is next considered. It is pointed out that if this is done the compression-cylinders are not subjected to the very high pressures and high temperatures produced by ignition, but, on the other hand, there is considerably more work performed in the compression-cylinders, as the gas has not only to be compressed, but also to be forced out of the cylinders. The extra work necessary for this may, however, for the most part, be returned by making the expansion-cylinder with a minimum of clearance, and arranging for the admitted charge by its pressure to force the piston some part of the stroke before ignition. By this arrangement separate compression and expansion could be arranged for without much loss of economy.

The arrangement permits of other advantages. As the clearance is minimised, there is practically no burnt gas left in the cylinder to unduly dilute the charge. The mean pressure can therefore be reduced in two ways—(1) by diluting the charge with excess of air down to the lowest firing proportion; and (2) by throttling the supply. It may also be possible to arrange for an earlier cut-off. Altogether the arrangement will permit a much lower mean pressure to be obtained than is possible with the four-stroke cycle. Further, by admitting only compressed air suitably throttled, the engine will work at very low speeds, in the same way that a steam-engine will work when throttled. An incidental advantage is the complete suppression of the two-to-one gear.

An installation which the author thinks would be suitable for marine purposes consists of an independent main engine driving the screw, having three double-acting expansion cylinders with three cranks set at equal angles. The compression is proposed to be effected by a separate engine without reversing-gear, having two sets of tandem engines, four cylinders in all, working on the four-stroke cycle driving two-stage air-and-gas compressors. The compressors would deliver into storage-receivers, from which the main engine would receive its charge.

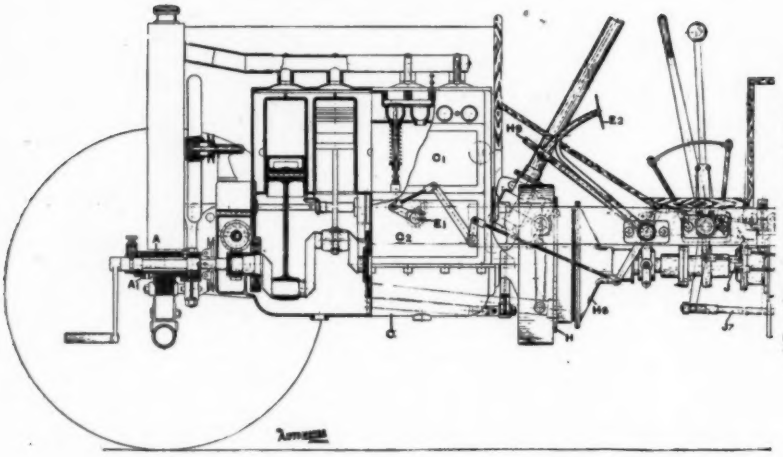
MOTOR ENGINEERING.

By ROBT. E. PHILLIPS, A.M.Inst.C.E., M.I.Mech.E.

The Deasy Car.

Through the courtesy of Captain Deasy, the founder of the Deasy Motor Car Co., we are able to supplement our description of this—the latest "All British" car—with a very complete set of illustrations. The car, which is the design of Mr. E. W. Lewis, the designer of the "Rover" and other cars, while not departing outwardly from accepted practice, contains many very novel features of construction. The main frame, although built up of wood with strong steel flitch-plates, is incurved at the front to increase the steering lock. It has cast-steel cross-members, two of which support the engine and a similar member, the gear box. The standard car has a wheel base of 10 ft. 1½ ins., but a longer chassis is built for special bodies which has a wheel base of 10 ft. 7½ ins. In all cases the track is 4 ft. 6 ins., and the tyres employed are 870 millimetres by 90 millimetres. A three-point suspension of the frame is obtained by the use of a transverse spring in front which is connected to the frame by a longitudinally arranged pivot. On the spring is centrally fixed a socket A^1 which is supported by a trunnion-pin A, carried by the frame. This construction permits the front axle with its spring to rock freely, even when the spring is not actually brought into play. Radius rods are employed to tie the front axle to the frame in the same way that the usual radius-rods at the rear connect the live axle with the frame. The transverse front spring is hinged direct to one steering-head forging carried by the front axle, and at the other end is coupled to the corresponding steering-head by a shackle so that it has perfectly free play in a lateral direction, while all other strains are taken by the radius rods before mentioned, which extend back from the knuckle-joints to points of the frame immediately beneath the dashboard. A single universal joint K is employed for the propeller-shaft B, as the said shaft is made to act as a torque rod for resisting the tendency of the back axle casing to rotate about its driving shafts by being enclosed in an aluminium casing B^1, which is bolted securely to the main casing. The "drive" is taken by the radius rods, and the torque by the propeller shaft. All strains, other than those due to the weight of the vehicle and to the inequalities of the road surface, are prevented from coming upon the rear springs by reason of the brackets A^3, which carry the springs, being freely mounted on the axle casing. Another bracket A^4 is hinged to the spring bracket, which carries the brake bands and the levers by which they are controlled, this arrangement having been adopted in order to prevent the action of the brakes from putting any twisting strains either upon the springs or upon the axle casing. Two brake bands are fitted to each of the driving wheels, which operate upon large drums bolted to the wheels. The bands are constructed of steel with iron liners, and are entirely supported by the toggle pins through which they are actuated. The foot-brake as well as the hand-brake is practically of an emergency character, owing to the utilisation of the engine as a brake. The differential casing of the back axle is made large enough to permit the gear ratio between the propeller shaft and the back axle being varied by the use of bevel wheels of different sizes. The cylinder dimensions are 105 millimetre bore and 130 millimetre stroke. The normal speed is 1,000 revolutions per minute, and at that speed 24-B.H.-P. is developed.

The four cylinders with their jacket and a skeleton frame for the crank chamber are cast in one piece. The two ends of the crank chamber, and a central partition plate that extends right across, are formed solid with the main frame, these being bored out to receive the ball races for the bearings that support the shafts. The base of the crank chamber is formed by the casting C, (Figs. 2 and 3) and the other side of the



(Continued on page opposite.)

FIG. I.—LONGITUDINAL SECTION
By courtesy of the "Automotor

engine is closed in by a cover plate C^2, which carries the magneto D^4 and the pump F. The crank chamber is completed by the use of cover-plates which are bolted in place on the frame. The valves are all located on one side of the cylinders, and the lifters and springs, &c., are enclosed in chambers covered by easily removable inspection plates. Inside the crank chamber are two other horizontal shafts, both of which are driven by means of spiral gear wheels from a transverse shaft D located in front of the engine, the said transverse shaft being driven from the crank-shaft by a pair of skew-wheels. One of the wheels D^1 on the transverse shaft D is considerably longer than the other, and is so mounted that it can be slid longitudinally in order to vary the relative "setting" of the shaft D^3, whilst the engine is running. This shaft operates the ignition, and also incidentally drives the water circulating pump, so that it is only necessary to slide the wheel D^1 in one direction or the other on the transverse shaft to vary the time of ignition, and also to cause the magneto always to give its full current. The other shaft D inside the crank chamber is the cam shaft, which is fitted with specially shaped cams, and is arranged to slide longitudinally to enable the engine to be used as a brake. The longitudinal motion of the shaft is controlled by a pedal E^3, which acts upon it through a rocking shaft E^1, which passes through one of the cover plates C^2. The longitudinal movement of the cam shaft causes the lift of both the inlet and the exhaust valves to be gradually reduced, and ultimately ceases to lift the inlet valves off their seats, while the exhaust valves are compelled to open at the completion of each upward stroke of the pistons, thus converting the engine into a single-acting 4-cylinder pump, which draws air or burnt gas into the cylinders during every down stroke of the pistons, and compresses it on the up-stroke thereof.

In the engine from which the illustrations were taken a high tension magneto is employed, low-tension make-and-break igniters being carried in the inspection plugs above the inlet valves. These are operated through two vertical shafts D^5, which are mounted in ball bearings and are driven by bevel wheels from the shaft D^2. Each shaft carries two cams for actuating the push rods for each igniter. When an auxiliary accumulator system is employed the commutator is fitted to the upper end of one of the vertical shafts D^5, and separate ignition plugs are fitted into the inspection covers over the exhaust valves. The igniters are readily removable, as the inspection plugs above the valves of each cylinder are held down in place by a single yoke and nut. The magneto D^4 and the pump are driven by a pair of spur wheels from the shaft D^3, the said gear wheels being enclosed inside the casing D^6. As flexible couplings are employed, either the magneto or the pump can be removed without difficulty. The pump consists of a series of small propellers, between each of which are

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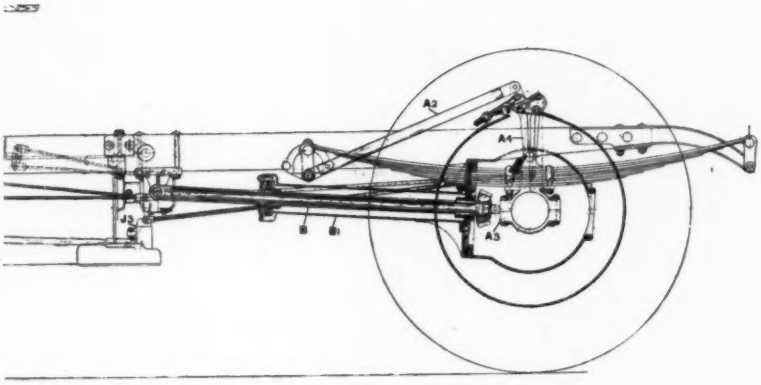


OF "DEASY" CHASSIS.
Journal" (Yellow Cover).

stationary deflectors so disposed as to ensure that all the propellers operate to cause the flow of water through the pump. The water is led from the pump through the branched pipe F^1, which delivers it into both ends of the jacket as well as into the centre. The return pipe F^2 to the radiator has a separate opening above each of the four cylinders. The induction and exhaust pipes are provided with taper ends which fit into slightly tapered holes in the main casing, and are held in place by yokes, each secured by a single nut. The exhaust pipe is made in five separate pieces which telescope into one another, but are not otherwise held in place. It will be noticed that sharp bends in the exhaust pipe have been avoided by leading it away from the front instead of the back end of the engine.

One of the special features of the carburettor consists in mounting the perforated sleeve G^3 (Fig. 5) by means of a coarse-pitch screw G^4 working in a similarly-threaded socket in the mixing chamber, whereby the sleeve normally tends to fall by gravity into its lowest position, so that a comparatively rich mixture is obtained when starting. As the suction inside the carburettor increases the sleeve G^3 is drawn in and the annular space around the spray jet is increased. At the same time the diagonally-arranged holes in the sleeve G^3 permits the explosive mixture to pass through said sleeve into the upper portion of the apparatus, thereby preventing the mixture from becoming too rich, and the throttling effect of the sleeve G^3 upon the

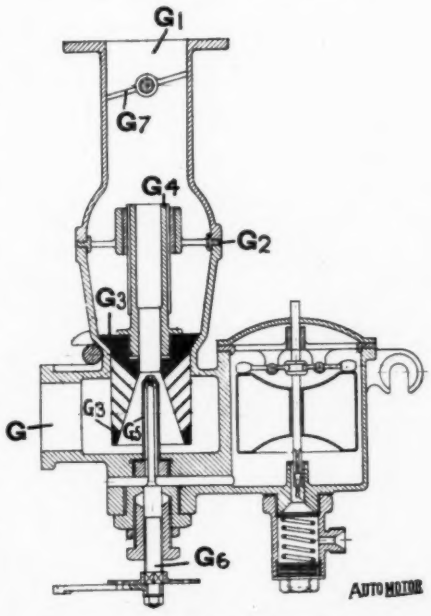
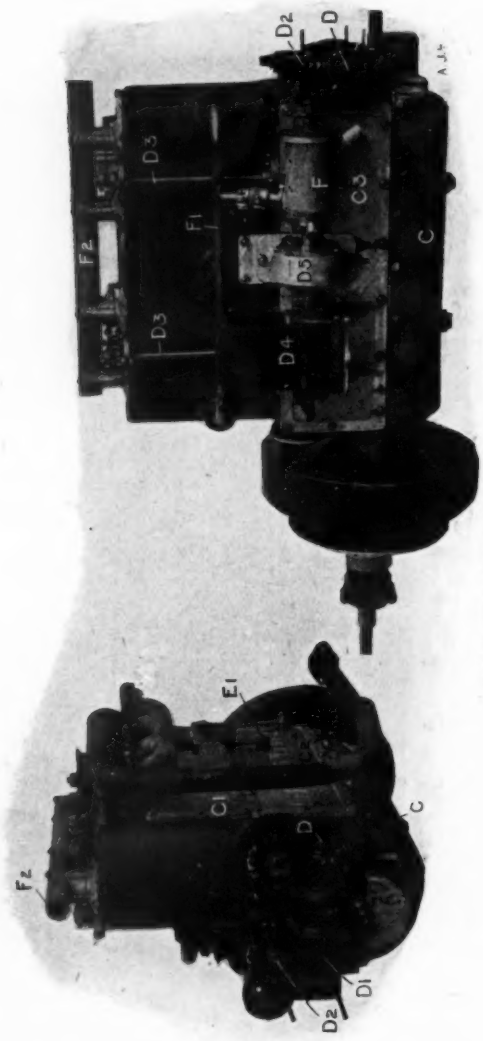


FIG. 5.—DETAILS OF CARBURETTOR.
By courtesy of the "Automotor Journal" (Yellow Cover).

in-going air is simultaneously reduced. The screw G^4 is employed to operate as a "dash-pot" to prevent the sleeve G^3 from moving up and down too rapidly. In practice it floats at a certain height, which depends upon the speed at which the engine is running and on the extent to which the hand-controlled throttle valve G^7 is opened. Another special feature of the carburettor is the employment of an adjustable spray-jet G^5, which is attained by the use of an internal needle G^6, which can be controlled by the driver to suit varying conditions. This adjustable jet is not intended to be manipulated frequently, but it forms a convenient method of compensating for different fuels of variations of climate. The clutch, which has only two metal discs, forms part of the flywheel, but can be detached bodily from it.



FIGS. 2 AND 3.—THE 24 H.-P. "DEASY" ENGINE.
By courtesy of the "Automotor Journal" (Yellow Cover).

The gear box gives four forward speeds and a reverse with a direct drive on the fourth speed, there being no independently sliding members on the main shaft J^1, and a wide intermediate spur wheel for the reverse. The changing mechanism is operated by a lever which is pivoted at its lower end and is provided with springs which normally keep it in a central position. This lever works in a quadrant which has a zigzag slot, so that the lever has to be moved alternately outwards and inwards when passing from one gear to another. The operating lever is coupled up with the changing mechanism by means of a rod operating a lever J^3 (Fig. 6), mounted on a spindle mounted in the main casing which forms the gear box. On the other end of the spindle is a toothed segment J^4, which meshes with a corresponding bevel pinion J^5 fixed to a longitudinal shaft, which carries a large cam drum J^6, the shaped slots of which cause the forks which engage the moving members to slide along and bring the required train of wheels into mesh. The main casing forming the gear box is bolted into place from beneath, and it has a large flat lid which enables the entire gear to be inspected, without trouble, at any time. The ball-bearings that support the shafts are so fitted that either shaft or any wheel

can be replaced without removing the gear box from the chassis. The universal joint of the propeller shaft consists of a forked forging K^1 (Fig. 7), which is fixed on the gear shaft J^1, and the other forked forging K^2, is fixed on the front end of the propeller shaft, the said forked forgings being connected together by a casing K, which provides bearing surfaces for their radial ends. Ball-bearings K^3, are introduced between the forked forgings and the casing, which is made for this purpose in two pieces, bolted together.

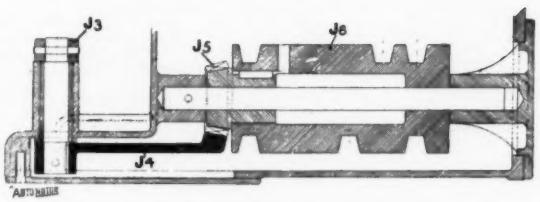


FIG. 6.—DETAILS OF CAM-DRUM.
By courtesy of the "Automotor Journal" (Yellow Cover).

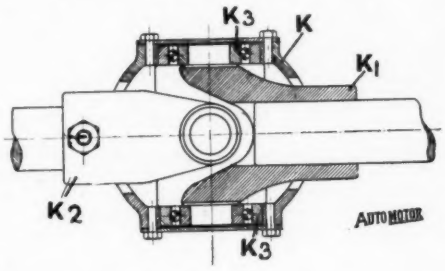


FIG 7.—DETAILS OF UNIVERSAL JOINT.
By courtesy of the "Automotor Journal" (Yellow Cover).

Self-starting Device.

The annual trial of self-starting devices for the "Prix Deutsch," held by the Automobile Club of France in connection with the annual Salon, has this year been won by the "Letombe" apparatus, which was fitted to a "De Dietrich" car, and has been taken up by the manufacturers of this car. The apparatus consists of an air compressor, a reservoir for the compressed air, and a distributor to the cylinders of the motor. The only novel feature of the air pump is the method employed to automatically cut it out of action when the maximum pressure is obtained in the reservoir. This consists of a spring-controlled piston above the delivery valve, which is connected with another spring-controlled piston—located above the suction-valve—which is normally held up against its spring by a catch. When the pressure in the reservoir reaches its maximum it overcomes the pressure of the spring of the piston above the delivery valve and forces the said piston upwards, which releases the piston above the suction valve, which is then pressed down by its spring until it contacts the suction valve and holds it open, thereby rendering the pump inoperative. When the pressure in the reservoir falls the spring of the piston above the delivery valve operates to restore both pistons to their normal positions The distributor, which is formed in one with the pump casing, consists of a chamber having as many distributing ports as there are cylinders to the engine, to which they are connected by pipes enlarged at their ends connected to the cylinders to contain non-return valves. Against the inner face of these ports is a rotary disc, having a single port, the said disc being driven through the pump, which is positively driven by the motor, the arrangement of the ports being such that one is always in communication with one of the cylinders of the motor in which the piston is on its working stroke. The disc is kept up to the face containing the ports by the pressure of the air admitted to the distributor from the reservoir, and a light spring is employed to operate to press the disc away from the said face when the apparatus is not in use, so as to avoid the friction between the disc and the face, the strength of the spring being such that it is easily overcome by the pressure of the compressed air when the valve between the reservoir and distributor is opened. To start the motor a positive screw-down valve, on the dashboard, is opened, and a spring-controlled valve adjoining the positive valve is then pressed open either by hand or foot, thereby admitting the compressed air from the reservoir to the distributor, by which it is at once admitted, first to one of the cylinders and then in sequence to the others, and so imparts motion to the motor until it starts working under its own power.

The Development of the Motor Omnibus.

The progress of the motor omnibus in London during the last twelve months is

strikingly shown by the following tables, the one showing the number of such vehicles owned by the various companies, and other proprietors, and the other the number of the various types of vehicles employed. It will be seen that whereas at the beginning of last year there were two hundred and twenty-eight motor omnibuses running in London there were at the beginning of the present year seven hundred and ninety-five, and it can safely be said that this number would have been materially greater but for the stringent action of the police towards the close of last year, which resulted not only in a large number of licensed vehicles being taken off the road, but also in a large number of new vehicles being refused licences. It will be noted that the "Milnes-Daimler" still heads the list in numerical strength, while the "Straker & Bussing" are not only a good second but show a considerably higher increase during the year.

OWNERS

	Jan., 1906.	Jan., 1907.
London Motor Omnibus Co., Ltd. ...	58	164
,, General Omnibus Co., Ltd. ...	23	163
,, Road Car Co.	53	130
,, Power Omnibus Co., Ltd. ...	12	57
Great Eastern London Motor Omnibus Co., Ltd.	4	48
London and District Omnibus Co., Ltd....	24	42
Thomas Tilling, Ltd.	16	32
Associated Omnibus Co., Ltd.	9	27
Star Omnibus Co., Ltd.	5	23
Motor Bus Co., Ltd.	—	19
Birch Bros., Ltd.	5	13
London and Provincial Motor Bus and Traction Co., Ltd.	—	11
Patrick Hearn	1	9
Victoria Omnibus Co., Ltd.	3	9
New London Surburban Omnibus Co., Ltd.	6	8

OWNERS—*continued.*

	Jan., 1906.	Jan., 1907.
London Standard Motor Omnibus Co., Ltd.	—	7
Burtwell Bros.	—	6
Henry Turner	3	6
Sharland Bros.	—	5
London and Westminster Motor Omnibus Co., Ltd.	—	5
Tom Hearn	—	3
Fred Newman	—	3
London Central Omnibus Co.	—	3
Balls Bros., Ltd.	—	1
Charles Freach	—	1
Mellish & Boffin	2	
City and Suburban	2	
	226	795

TYPES OF VEHICLES.

	Jan., 1906.	Jan., 1907.
Milnes-Daimler	104	238
Sidney Straker and Squire & Bussing ...	38	217
De Dion Bouton	12	104
Scott-Stirling	12	57
Clarkson...	1	43
Germain	13	
Durkopp...	24	31
Lacoste & Battmann	—	29
Scheibler	1	20
Eugene Brillie	2	15
Lancashire Steam Motor Co.	9	11
Orion	6	9
Motor Omnibus Construction Co. ...	—	8
Maudslay	—	6
Thornycroft	—	3
Dennis	—	2
New Arrol-Johnston	—	1
Wolseley	4	1
	226	795

NEW MACHINERY AND APPLIANCES.

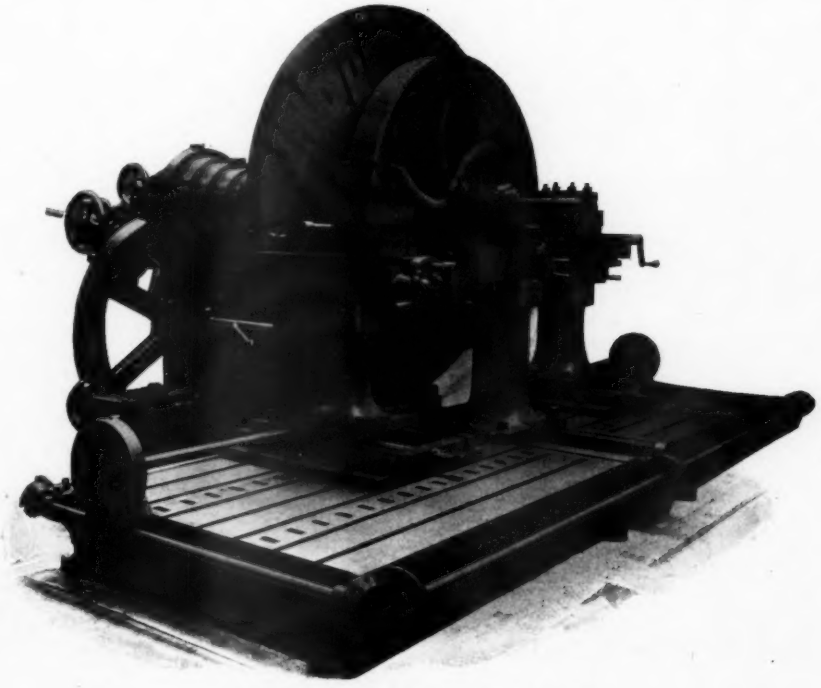
The Editor cordially invites early particulars of New Machinery, Improvements, Novelties, &c., for inclusion under this section.

Fly-wheel Boring, Turning, and Bossing Lathe.

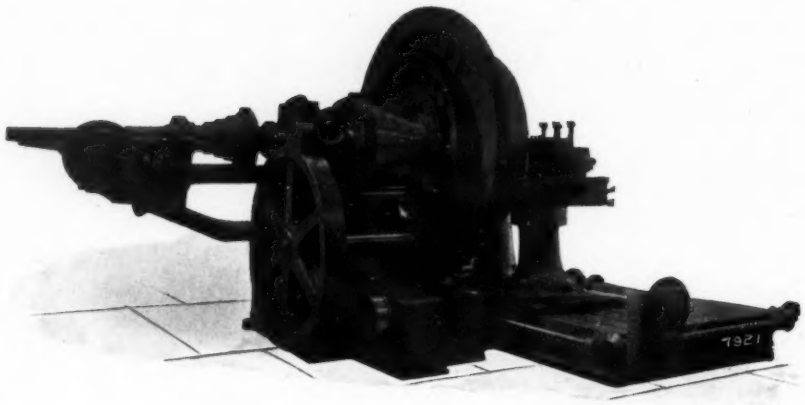
The machine forming the subject of the accompanying illustrations has been specially designed for dealing with gas engine and other fly-wheels. It is capable of finishing a fly-wheel at one setting; that is, of turning the face, rims, inside and outside of the boss, and boring the holes—six tools being in operation at once.

The headstock and rests are mounted on a massive baseplate, which makes the lathe self-contained and ensures perfect rigidity. The headstock is of special construction, and is very massive in all its parts.

The faceplate is supported by an improved roller bearing on the headstock, and



FLY-WHEEL BORING, TURNING, AND BOSSING LATHE.



FLY-WHEEL BORING, TURNING, AND BOSSING LATHE.

is securely bolted to the flange of the main spindle, which is a large forged steel cylinder, revolving in gun-metal bearings. A long cast-iron sleeve is held stationary inside this cylinder, and carries on the end a facing arm for facing the inside of the boss. This is self-acting, by screw feed. A self-acting forward motion is also fitted to the facing arm sleeve for turning the inside bosses. Inside this fixed sleeve the boring bar revolves for turning out the hole of the fly-wheel. This boring bar is independent of the lathe in its motion, and is, in fact, as will be seen from the illustration, a complete horizontal boring machine attached to the headstock, and driven from a separate countershaft overhead, so that it may be kept running while the lathe is standing.

Six quick changes of continuous feeds are given to the rest by gearing, each rest having a vertical shaft in the centre of the column, worked by mitre gearing and splined shafts round the baseplate from a change feed box, with six changes, which has separate driving motion by pulleys on the countershaft. The speed is engaged and disengaged by a friction device on each rest, so that it is within easy reach of the operator. The rests are made specially massive and strong to bear high speed cutting.

The driving cone and gearing are carefully calculated to give uniform gradations of speed and power, and the machine combines a really up-to-date turning lathe for engineering work with a most economical and efficient special tool for fly-wheels.

All gearing is machine cut, and cast iron covers provided where necessary.

Complete countershaft with two speeds, belt-shifting gear, &c., is provided.

The following are details of capacity and dimensions:—

It will turn over baseplate 10 ft.; will admit from faceplate to front of centre pillar rest 4 ft. 6 ins.; will admit in front of jig a flywheel 21 ins. wide. Diameter of faceplate, 8 ft.
Front bearing of spindle, 16 ins. dia. by 12 ins. long.
Driving cone, 5 speeds $5\frac{3}{8}$ ins. wide. Diameter of largest, 26 ins.
Maximum gear power, 165 to 1.
Variation of feed for turning rest:—Front 6 changes from 2 to 24; centre 6 changes from 14 to 168; back changes from 5 to 60.
Boring bar: length of travel, 16 ins. by $3\frac{1}{2}$ ins. dia.
Cone, 4 speeds $3\frac{1}{4}$ ins. wide. Diameter of largest, $13\frac{1}{2}$ ins.
Facing arm will face in diameter 21 ins
Distance from faceplate to cutting tool, $8\frac{3}{4}$ ins.
Floor space, 22 ft. 6 ins. by 17 ft.
Approximate weight, 29 tons.

The machine was built by Messrs. Butler & Co., Halifax, to the order of the Dudbridge Iron Works.

Clinker Screening and Handling Plant.

In these days of keen competition the utilisation of waste products forms a very important factor in cost of production, and nowhere has this been better demonstrated

than in connection with the utilisation of the huge heaps of clinker throughout the country, and the values put upon the residues from destructors and furnaces of all descriptions. The accompanying illustration shows one of the specialities designed and manufactured by the Lowca Engineering Co., Ltd., of Whitehaven, for handling these residues. The clinker is brought to the foot of the elevator by small tip waggons and is dumped into the boot whence it is raised to the screen placed over the storage bunkers. The screens are at present made in four sizes and are constructed on the "Zimmer" patent balanced system, the Lowca Co., being the sole makers in this country. The screens are strongly built, and possess some novel and interesting features. They consist of flat troughs with perforated bottoms, and the whole of the screening action may therefore be watched and foreign matter picked out. The plates are readily changed for the various requirements of the market. If at any later period further sizes are necessary it is a simple matter to add more bunkers and lengthen the screens. Another feature is a special apparatus provided so that the screens may be so adjusted before starting that the driving rods must always be in tension and the spring legs of the screen entirely relieved of the load. The plant illustrated has its screen in duplicate, is capable of dealing with one ton per minute, and is driven by an undertype semi-portable steam engine, but others have been constructed driven by gas, oil and electricity. In many cases large percentages of coke have been found in the clinker in which case a combination of the above plant with a washery has been most effective. The Lowca Co. are at present constructing a large installation for this purpose for one of the largest gas companies.

CLINKER SCREENING AND HANDLING PLANT.

METALLURGICAL PROGRESS.

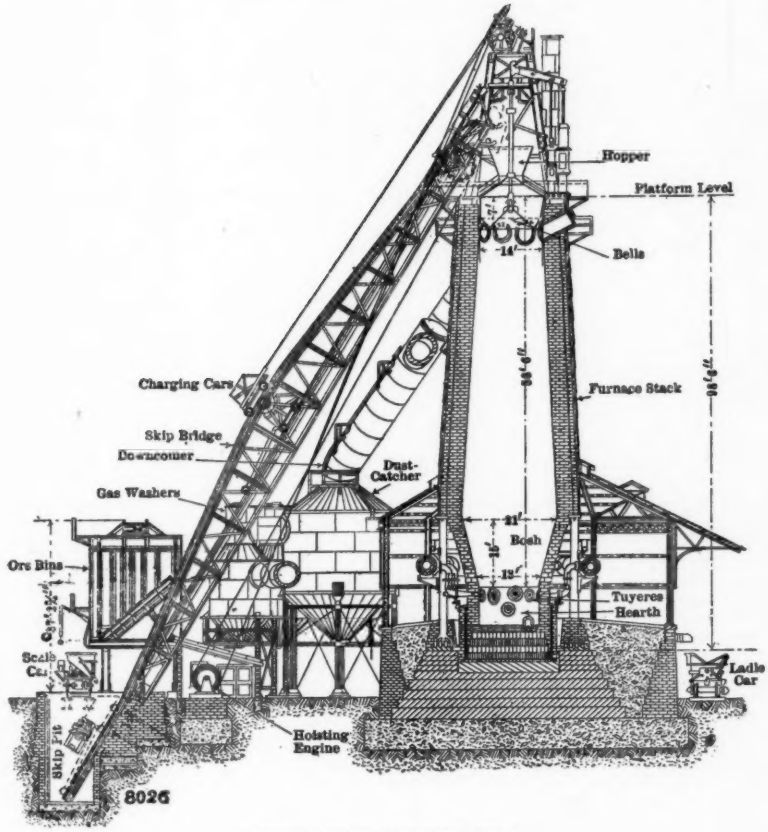
By PERCY LONGMUIR.

BLAST FURNACE PRACTICE.

Chattanooga Furnace of the Southern Steel Co.—A description of this furnace which has recently been rebuilt appears in a late issue of the *Iron Trade Review*. The furnace is 16 ft. in diameter at the bosh and 75 ft. high and has a capacity of 200 tons of pig iron per 24 hours. A skip hoist of 80 cubic ft. capacity elevates raw material to the top of the furnace which is fitted with a "Brown" hoist top and distributor. The chief features of this hoist and distributor are the bridge, top frame work, bell beams and bell trolleys, bell, and hopper, distributing device and rotating mechanism. The bridge consists of an inclined steel truss of the parabolic type, reaching from a pit in the stock house to the top of the furnace. The skip car travels on T rails laid on the bridge. The top frame work of steel construction is located at the top of the furnace platform which supports the rails carrying the skip car. These are continuations of the rails on the bridge and are curved in such a manner as to carry the car in over the hopper. Just outside these rails, starting at a point near the level of the platform, a second set of rails is arranged to take an outside pair of wheels in such a manner that the front end of the car runs in on the curved rails while the rear wheels are carried on a line parallel, or nearly so, to the rails on the bridge, thereby raising the car and dumping the load into the bell. The distributing hopper is of cast iron with a curved spout at the lower end which directs the material to one side of the bell. The lower end of the spout is fitted with a door which closes when the bell is lowered thus preventing an escape of gas. The spout and hopper are revolved by suitable mechanism in order to evenly distribute the charges. The projecting beams shown in the illustration are used to remove the distributor and top from the furnace and hold it at one side whilst repairs are being made. The furnace is installed at one end of a cast house 60 ft. by 200 ft. A narrow gauge track along the centre of the floor deals with the cast pigs taking them out to breaking blocks where they are graded and stacked in a storage yard. The stock house is a building 34 ft. by 400 ft and built in two levels with a pit under the lowest level for the reception of the skip car. A double track is laid through the upper level, on which supplies are brought in and dumped into bins directly under the track. A motor driven stock car runs along the track on the lower level of the stock house, receives its supplies of ore, coke and limestone from the various bins and discharges them into the skip car. Further equipment includes four stoves each 18 ft. by 16 ft.; one dust catcher and one equaliser 20 ft. by 20 ft. together with four blowing engines.

Blast Furnaces at the Minnequa Steel Works.—These furnaces are described by Mr. L. Lewis in the *Engineering and Mining Journal*. The three new furnaces are each 20 ft. in diameter and are respectively 95, 95 and 90 ft. in height and each one has an average capacity of 400 tons per 24 hours. The equipment comprises, "Rust" automatic hoists, the chief features of which may be seen in Fig. 1. The two downcomer connections meet as shown in Fig. 1, forming one central flue which terminates at the top of a dust catcher 24 ft. in diameter. To the dust catcher are connected two vertical gas washers, from one of which the gas main leads to the boilers, while the other opens into the gas main leading to the stoves. The molten metal is tapped into ladles and conveyed direct to the steel departments or to pig casting machines. Fig. 1, giving a vertical section of one of the furnaces, shows full details as to construction and method of working.

Australian Iron.—Mr. J. Plummer, writing in the *Mining World*, states that the experimental shipment of 2000 tons of iron ore from South Australia to Europe, the first from the Antipodes, is destined, if successful, to mark the commencement of a new chapter in the mineral history of the commonwealth. Although the metal is distributed over the whole of Australia, deposits in several places being exceptionally large, little use has hitherto been made of the ore save for fluxing. The writer, after giving statistics of imports and referring to the action of the New South Wales Government in encouraging local production, describes the various deposits of iron ore known in Australia.



VERTICAL SECTION OF BLAST FURNACE.

STEEL: ITS PROPERTIES AND TREATMENT.

Electric Furnace Methods of Iron and Steel Production.*—In this, the concluding article of a series, Mr. J. B. C. Kershaw discusses yield and costs, noting at the outset the enormous mass of statistics which have been published and the variations found on reducing these figures to a common basis of comparison. Variables are also found in the fact that many published figures are estimates; further, variations in the cost of power and in different methods of working contribute to variation in the cost per ton of finished steel. However, comparisons between yields and costs for different furnaces and processes are only made when the conditions under which the trials were carried out are similar in character and a fair comparison is possible. The data thus obtained is summarised in the following table giving kilowatt hours per ton of 2,000 lbs.

These results show that in the production of steel from cold charged scrap and pig the Héroult, Kjellin, and Keller furnaces all give figures in the vicinity of 800 kilowatt hours; whilst the Stassano and Girod furnaces have a power consumption 50 per cent. higher. Both the Héroult and Keller processes are able to deal with more impure materials than the Kjellin process, since the electric arc produces a much higher temperature than induction heating, and this facilitates the oxidation and removal into the slag of the impurities present. However, the Kjellin process gains by the absence of carbon electrodes and by the generation of heat entirely within the materials

* *Iron Trade Review.*

	I. Heroult.	II. Keller.	III. Kjellin.	IV. Stassano.	V. Gin.	VI. Girod.	VII. Harmet.
Steel from scrap and pig (charged cold) ...	864	730	866	1,164	..	1,136	..
Same (charged hot)	320	631	..	..	618	..	..
Pig iron from ore, coke, and lime (charged cold)	2,693	2,292	..	..	..	..	..
Same (charged hot)	..	..	..	..	..	..	..
Steel from ore, coke, and lime (charged cold)	..	2,800	..	2,804	..	..	1,038
Nickel pig from ore	2,342	..	..	..	..	..	..

(NOTE TO TABLE.—All results in K. W. hrs. per ton of 2,000 lbs.)

contained in the furnace. Maintenance and operating costs are thus reduced, and this saving balances the greater cost of raw materials. Turning to the reduction of ores and the production of pig iron or steel in one operation, the author shows results to be less hopeful than those already given. With materials charged cold the power consumption in the case of pig iron lies between 2,300 and 2,700 kilowatt hours. With preliminary heating a reduction of from 300 to 500 kilowatts is possible, but it is improbable that the power required for producing iron or steel direct, even with preliminary heating, can be reduced below 2,000 kilowatt hours per short ton of metal. This limits the industrial development of the electric furnace for iron ore reduction except in very special cases.

Whilst the figures given for power consumption are mostly based on actual trials, published working costs are based on estimates rather than actual figures. A series of costs for the various electric processes are given, but, as the author states, they show such wide variations that even as estimates they are misleading and unsatisfactory. In attempting to form an opinion as to the comparative cost of the various processes, it is better to rely upon the figures given for power consumption. Taking the estimated h.-p. per year at $10·00 and the average power consumptions given in column I. of the table, results in the following costs :—

(1) Steel from molten scrap ... ... $0·62
(400 kilowatt hours.)
(2) Steel from cold scrap and pig ... $1·24
(800 kilowatt hours.)
(3) Pig from ore, coke, and lime, charged cold ... ... $3·87
(2,500 kilowatt hours.)
(4) Pig from ore, coke, and lime, charged hot ... ... $3·10
(2,000 kilowatt hours.)

In the production of crucible steel it is customary to assume a coke consumption of from 2½ to 3 tons per ton of steel produced. With coke at $4·00, the advantage is therefore on the side of the electric furnace. As regards electric smelting processes, it must be remembered that coke is required to reduce the iron ore, and the only fuel saved is that used in the blast furnace for heating purposes. In the best modern smelting practice only 1,600 lbs. of coke are required per ton of pig iron produced, and of this total 650 lbs. are required to reduce the ore. The saving in coke by the electric furnace method of smelting cannot therefore exceed 950 lbs., or, at present price of coke, $2·00. These considerations show that the prospect for the electric refining processes are much brighter than those for the electric smelting processes—since the saving of coke in the latter is too small to balance the large expenditure upon electric power. The h.-p. per year would in fact have to be supplied at the extraordinarily low cost of $5·00 to compete with the blast furnace.

Molybdenum in High Speed Steels.—Mr. F. W. Taylor, in his presidential address to the American Society of Engineers, gives much of direct value on the art of cutting metals. Incidentally the following extract has a metallurgical interest. Mr. White and the writer stated in a patent that molybdenum can replace tungsten in high speed steels, and that one part of the former will produce approximately the same effect as two parts of the latter. During the development of the "Taylor-White" process, from 4 to 4½ per cent. of molybdenum appeared to be a sufficient quantity to make a high speed tool; whereas about 8 per cent. of tungsten was required for this purpose. However, these tools were brittle, had a tendency to fire crack, were weak in body, or else irregular in their cutting speeds, thus giving faults of a serious nature. The irregularity in molybdenum tools constitutes, perhaps, its most characteristic feature. By irregularity is meant that tools of the same chemical composition and apparently treated alike give large variations in cutting speed. The cause of this irregularity has not been determined, but one explanation may be found in the fact that molybdenum tools appear to run at their highest cutting speeds when treated at a slightly lower heat than that required to produce a first-class tungsten-chromium tool. It may be that when the molybdenum tool is heated beyond that precise temperature necessary to make it a first-class tool, it deteriorates. One of the most successful characteristics in the modern tungsten-chromium high speed tool is that it requires little or no skill in order to heat it up close to the melting point, and that the tool itself shows clearly by its appearance when the right heat has been reached. Moreover, it is impossible to injure the cutting properties of these tools, even

TABLE I.

Alloy No.	Aluminium, per cent.	Sand Castings. Yield Point. Tons per sq. in.	Sand Castings. Ultimate Stress. Tons per sq. in.	Sand Castings. Elongation, per cent. on 2 ins.	Chill Castings. Yield Point. Tons per sq. in.	Chill Castings. Ultimate Stress. Tons per sq. in.	Chill Castings. Elongation, per cent. on 2 ins.	Bars rolled to $\frac{1}{2}\frac{3}{8}$ inch diameter. Yield Point. Tons per sq. in.	Bars rolled to $\frac{1}{2}\frac{3}{8}$ inch diameter. Ultimate Stress. Tons per sq. in.	Bars rolled to $\frac{1}{2}\frac{3}{8}$ inch diameter. Elongation, per cent. on 2 ins.	Bars rolled to $\frac{1}{2}\frac{3}{8}$ inch diameter. Reduction of Area.
1	0·10	3·8	11·50	46·0	4·1	11·53	46·0	6·9	14·50	65·5	90·71
2	1·06	3·0	13·40	52·0	5·2	11·80	53·0	6·9	15·88	61·0	88·63
3	2·10	3·4	13·50	53·5	4·5	13·70	54·5	8·6	17·46	56·5	89·65
4	2·99	3·8	14·50	60·0	6·8	13·80	60·0	11·6	19·79	57·2	86·11
5	4·05	3·5	16·70	83·0	4·9	17·10	82·0	11·3	23·80	67·0	83·27
6	5·07	4·3	18·10	75·0	7·1	18·10	60·5	11·4	26·41	69·2	77·80
7	5·76	4·8	17·80	67·0	6·0	18·80	61·0	11·8	28·40	74·2	76·93
8	6·73	4·8	18·65	could not be measured	not taken	19·96	69·0	10·4	28·85	71·0	75·02
9	7·35	6·6	21·30	71·0	not taken	21·58	84·0	10·6	29·68	72·5	74·34
10	8·12	7·7	24·91	58·0	9·7	27·47	62·0	13·0	33·22	51·5	60·40
11	8·67	9·8	28·10	48·0	not taken	30·80	55·0	11·1	36·67	38·0	50·66
12	9·38	9·7	30·38	36·2	10·5	33·98	43·5	17·7	38·00	34·0	33·60
13	9·90	11·3	31·70	21·7	12·4	36·93	30·5	14·8	38·10	28·8	30·80
14	10·78	14·1	29·52	9·0	16·9	36·73	9·0	15·4	38·62	14·0	18·60
15	11·73	14·0	25·43	5·0	14·8	30·63	6·0	12·6	33·85	8·5	15·37
16	13·02	coincident with fracture	19·75	1·0	coincident with fracture	25·06	nil.	—	37·14	2·0	1·87

if they are heated to a point at which the thinner or sharper edges begin to melt. The difficulty of judging by eye an exact high temperature reached by a tool when near its melting point is so great that if a definite treating temperature were required—that is, if tools were injured by heating beyond this temperature—much of the value of the high speed tools would be lost.

GENERAL METALLURGY.

Eighth Report to the Alloys Research Committee on the Properties of Alloys of Aluminium and Copper.—In this report Messrs. Carpenter and Edwards record an extensive series of tests on the properties of copper alloyed with aluminium, and also on the properties of aluminium alloyed with copper. The research is based on a scheme drafted by Longmuir, and has been carried out in co-operation with the Broughton Copper Co. and The British Aluminium Co. On the whole the report is one of the most useful yet issued by the committee, and the authors and co-operating firms are to be congratulated on issuing matter of really valuable and practical character, features which have not been conspicuous in previous reports. As the report covers some two hundred pages, containing forty-seven figures in the text and twenty plates of micrographs, it is obviously difficult to condense, but in the following some effort is made to give its leading features.

The alloys were melted in an oil furnace, and experiments made under the author's conditions show that remelting for the production of sound alloys is unnecessary and the first cast is equal in properties to any subsequent ones. This applies only to small castings; with large ones remelting may constitute the best practical method of ensuring homogeneity. From each alloy a series of sand and chill castings were obtained as well as ingots for subsequent rolling. The tensile

TABLE II.

Alloy No.	Aluminium per cent.	Shape and Size of Test Piece.	Alternations endured under Standard Conditions. First Test.	Second Test.	Mean.	Remarks on Quality of the Alloy.
1	0·10	$\frac{3}{8}$ in. round, $5\frac{1}{2}$ ins. long	308	266	287	Fair.
4	2·99	" "	330	334	332	Good.
6	5·07	" "	658	606	632	Very good.
9	7·35	" "	1,530	1,260	1,395	Excellent.
13	9·90	" "	707	607	657	Very good.
1	0·10	$\frac{3}{8}$ in. square, $5\frac{1}{2}$ ins. long.	430	456	443	Good.
4	2·99	" "	432	480	456	Good.
6	5·07	" "	894	734	814	Very good.
9	7·35	" "	1,280	1,466	1,373	Excellent.
13	9·90	" "	810	756	783	Very good.

TABLE III.

Alloy No.	Copper per cent.	Sand Castings. Yield Point. Tons per sq. in.	Sand Castings. Ultimate Stress. Tons per sq. in.	Sand Castings. Elongation per cent. on 2 ins.	Sand Castings. Reduction of area, per cent.	Chill Castings. Yield Point. Tons per sq. in.	Chill Castings. Ultimate Stress. Tons per sq. in.	Chill Castings. Elongation per cent. on 2 ins.	Chill Castings. Reduction of area, per cent.	Bars rolled to $\frac{1}{2}\frac{3}{2}$ in. dia. Yield Point. Tons per sq. in.	Bars rolled to $\frac{1}{2}\frac{3}{2}$ in. dia. Ultimate Stress. Tons per sq. in.	Bars rolled to $\frac{1}{2}\frac{3}{2}$ in. dia. Elongation per cent. on 2 ins.	Bars rolled to $\frac{1}{2}\frac{3}{2}$ in. dia. Reduction of area, per cent.
33	0·00	2·5	4·90	24·0	39·42	2·3	5·22	37·0	60·70	6·5	7·20	30·5	81·20
34	0·86	2·6	5·12	12·5	12·11	3·1	6·12	15·5	33·25	7·6	10·47	28·5	73·33
35	1·90	3·3	4·57	5·5	18·44	3·9	8·18	17·0	26·44	12·8	14·36	19·0	38·16
36	2·77	3·7	5·22	4·5	10·96	4·9	8·60	10·5	24·57	12·5	16·57	16·0	44·60
37	3·76	4·9	7·49	5·0	7·28	5·4	9·60	10·5	21·46	11·6	17·00	21·0	49·76
38	4·97	5·2	6·73	4·0	5·00	5·9	9·62	6·0	9·66	10·4	15·15	19·5	36·40
39	6·15	6·1	7·72	Broke outside gauge marks.	3·50	5·3	9·92	5·0	10·60	13·1	17·27	15·5	33·60
40	6·91	5·2	6·14	2·0	1·60	6·1	9·42	4·0	4·62	12·2	16·05	14·5	27·60
41	8·08	6·5	7·40	Broke outside gauge marks.	1·99	7·2	10·65	Broke outside gauge marks.	1·60	11·0	15·31	17·5	27·60

properties of these three conditions are shown in Table I.

These tests give a very good index of the properties of the high copper alloys, but it should be noted that they represent untreated material, further than that of rolling in the case of rolled bars. Torsion tests show extremely good results with alloys up to 7½ per cent. aluminium, but beyond this there is a rapid fall in properties. Alloys submitted by Professor Arnold to his alternating stress test gave the values shown in Table II.

Impact tests carried out on the "Izod" machine give results which, owing to the fact that some members of the series have not broken, are of comparatively little value.

Turning to the rich aluminium alloys the tensile properties may be summarised as before by combining a series of tables in order to produce one table in which the effect of condition is shown comparatively. See Table III., which represents cast and worked material in the untreated condition.

A series of tests of the alloys in the form of sheet are given, the respective thicknesses to which the sheets have been reduced being 0·25, 0·10 and 0·05 inches respectively. Tensile properties of the last are embodied in Table IV., showing the two conditions of unannealed and annealed.

Corrosion tests in fresh and sea water have shown the alloys high in aluminium to be strongly corroded by the latter but not by the former. Alloys high in copper behave differently, being uncorroded by sea water and slightly but quite appreciably corroded by fresh water.

Other features lie in the fact that the authors find "hardly any change of composition" on remelting, a statement which does not coincide with usual experience, and that a protected thermo couple gives practically the same reading as a bare couple. Thus the error due to protection at 1000° C. is extremely small, being well within the limits of experimental error, whilst at a temperature in the near vicinity of 600° C. the error due to protection is not more than 8° C.

These figures are interesting, but, until more definite data is published by competent workers, should be accepted with some reserve.

TABLE IV.

Alloy No.	Copper.	Condition.	Yield Point. Tons per sq. in.	Ultimate Stress. Tons per sq. in.	Elastic Ratio.	Elongation per cent. on 3 ins.
42	0·00	Unannealed	8·4	9·34	0·90	3·7
43	0·93	,,	11·7	12·16	0·96	3·3
44	1·57	,,	13·8	15·16	0·91	3·3
45	2·36	,,	15·3	16·85	0·91	4·0
46	3·74	,,	15·9	18·56	0·85	4·0
47	4·74	,,	14·7	16·77	0·88	4·0
48	5·34	,,	14·3	16·52	0·87	Broke outside gauge marks.
42	0·00	Annealed at about 500° C. 932° F.	3·2	5·83	0·55	36·3
43	0·93	,,	3·4	8·46	0·40	29·2
44	1·57	,,	4·1	10·61	0·39	25·7
45	2·36	,,	4·5	11·76	0·38	24·7
46	3·74	,,	4·9	11·66	0·42	24·7
47	4·74	,,	4·8	11·93	0·40	18·7
48	5·34	,,	5·6	12·16	0·46	21·7

The Engineer's Book-shelf

Manual of Wireless Telegraphy. By A. Frederick Collins. 1906. (London: Chapman and Hall, Ltd.) 8s. 6d. net.

That which distinguishes this book from other works on wireless telegraphy is that it is written especially for those who are, or desire to be, engaged in the practical operation of wireless stations or systems. Clearly such a person must know something of the theory, if he is to be more than a mere machine when he comes to handle apparatus; but the author is properly content to devote but little space to this side of the subject, which can be learned elsewhere, and is therefore able to devote his attention mainly to practical matters. In an early chapter, however, he gives a brief discussion of the main points in elementary theory, which, though by no means exhaustive, is sufficient to make the reader familiar with the ideas which are constantly in use later on. When once the ground has thus been cleared, the author turns to a detailed examination of apparatus. Chapter III. takes each element in the apparatus of a wireless telegraphy station in turn and explains its functions and its operation. Chapter IV. deals with the aerial wire system and discusses the different forms and arrangements in use on land and sea. The two following chapters give an analysis of wiring diagrams for transmitters and receivers of various systems, and these are followed by two very practical chapters dealing with the apparatus in action and the adjustment and operation of instruments. Chapter IX. gives a little of the history of different makes of equipment—Marconi, Telefunken, Fessenden, de Forest, and Clark—while the final chapter of the volume contains suggestions to operators, and a good deal of information regarding the distribution on land and sea of Marconi stations, de Forest stations, and United States army and navy wireless stations. An interesting chart is given showing how the Marconi Company is able to locate liners equipped with their apparatus, and so to communicate with a vessel from land and, if need be, have the message sent on again to another vessel further off.

The whole volume is very readable, and the discussion and analysis of the apparatus and its operation very clear and practical, so that it should be really useful to those who are engaged in this work. The diagrams are very numerous and are all excellently reproduced. In a work of this kind, the diagrams are all-important, as the eye can take in an arrangement shown by a diagram much more quickly than the mind can grasp it from descriptions in the text; and it is satisfactory to find that the author has made such good use of this means of instruction, and has taken pains to make the diagrams exceedingly clear.

Elementary Principles of Continuous-Current Dynamo Design. By H. M. Hobart, B.Sc., M.I.E.E. (London: Whittaker & Co.) 7s. 6d. net

The author assumes an intimate acquaintance with the fundamental principles of electricity and magnetism, and the reader so equipped should find this work one of the most useful of its kind. The valuable feature of the work is that, apart from the curves and other graphic representations of the phenomena and the physical, magnetic, and electric properties of the material handled, Mr. Hobart has put before the budding designer a large amount of data relating to actual designs. These are tabulated with evident care and discrimination, and justify one in saying that, from this point of view alone, the author has earned the gratitude of the seeker after knowledge, inasmuch as he has put into the hands of his readers much information which other authors have either neglected to give, or presented in such a form that the wheat could be sifted from the chaff only after a great deal of labour.

The treatment of sparking and the general theory of commutation is excellent, and for the first time in the literature of dynamo-electric machinery, reversing poles for turbo-dynamos has received adequate treatment. The subject does not bristle with difficulties, but the budding designer does want a helping hand on a subject which, probably because of its recent introduction into the province of the designer, has not received much attention in contemporary literature.

Commercial considerations have not been neglected, and the data as to the cost of material in various designs should enable the student to steer clear of expensive designs, which is, after all, the ultimate aim of applied science.

Electric Railway Engineering. By H. F. PARSHALL, M.Inst.C.E., and H. M. HOBART, M.I.E.E. (London: Archibald Constable & Co., Ltd.) 1907. Price, 42s. net.

The names of the authors and their wide experience is perhaps a guarantee that any work of magnitude undertaken by them—as, for example, the present volume—would be valuable, authoritative and complete.

Even this statement is inadequate as applied to the present volume, as it fails to convey an idea of our opinion of the work—without question one of the best of its kind we have had the privilege of noticing. Although the book does not pretend to cover the whole ground of electric railway practice what is dealt with is done well, and those interested in the subject will find in an accessible form the valuable results of the authors' own observations and experience in this very increasingly important department of electrical engineering. Further, the adequate references to and quotations from the works of other authors render the volume increasingly useful. The subject-matter is divided into three sections. The first deals with the mechanics of electric traction with chapters on tractive resistance at constant speed, acceleration, tractive force and energy at the axles, and finally a study of the characteristics of electric railway motors and of section characteristics, and the construction of load curves. Section II. is devoted to the generation and transmission of electrical energy. Section III. to rolling stock, the latter including a separate chapter on trucks.

We should have expected to find perhaps in a work of this character some space devoted to track design and construction, and that rail phenomena, such as corrugation, would have been dealt with, but the amount of time that has evidently been already spent on the volume precluded the treatment of these subjects.

The important subject of wheels, their composition in relation to wear, &c., perhaps justifies a more detailed treatment than is accorded, especially in view of the extensive trials and investigations that have been carried out in the last two or three years, particularly in America, but curtailment here has been probably due to the above-mentioned reason.

Of the printing and illustrations we can only say that both are superb and reflect the highest credit on all concerned.

Sanitary Engineering with Respect to Water Supply and Sewage Disposal. By L. F. VERNON HARCOURT, M.Inst.C.E. (London: Longmans, Green & Co., 39, Paternoster Row, E.C.) Price. 14s. net.

This work forms another welcome addition to the popular Civil Engineering Series issued by Messrs. Longman, and may be said to form a complement to the author's other volume in the series dealing with civil engineering as applied in construction. The full and exact treatment accorded to two subjects of such importance as Water Supply and Sewage Disposal should render the work acceptable and useful to engineers concerned therewith, and at the same time the general engineering reader will find in it a vast amount of interest and information.

The important subject of Bacterial Treatment of Sewage has, perhaps, not received such detailed consideration as it deserves, or as would render it of value to the specialist, but as a general explanation of the processes involved it is very lucid.

We cordially recommend the book.

Historic Locomotives. By ALFRED R. BENNETT, M.I.E.E. (London: Cassell & Co., Ltd.). 1906. Price 2s. 6d.

The object of the author has been to rescue from oblivion the details and appearance of famous locomotives of the mid-Victorian era. By railway enthusiasts this volume will undoubtedly be highly appreciated, as many of the engines described and depicted are of the most interesting character.

Amongst them may be mentioned the Broad Gauge "Great Western," the "Milo" of the London and South Western Rallway, Bristol and Exeter Broad Gauge Engine, No. 42, the ill-fated North British Engine, No. 224, and several "Crampton" engines of the South Eastern line.

Mr. Bennett has succeeded in making his letterpress very readable, and the artist, Mr. E. W. Twining, is to be congratulated on his excellent series of water-colour drawings from which the plates have been reproduced.

The author's efforts in urging the desirability of establishing a national locomotive museum, similar to the Marshall Field Museum at Chicago, are well known, and in the absence of such an institution the present work will form a valuable record, especially as it becomes more difficult as time goes on to recover information respecting engines which formed interesting features of railway progress.

Locomotives of 1906. By CHAS. S. LAKE. (London: Percival Marshall & Co.). Price 1s. net.

This volume, though complete in itself, has been written mainly with the object of continuing the survey of modern locomotive practice provided by the author in his larger and very complete work, "The World's Locomotives."

All the more noteworthy British and foreign engines constructed during the year—and there were many—receive attention; thus those possessing the original work will have a convenient and inexpensive means of keeping it fully up-to-date.

THE ENGINEERING PRESS.

In this section is presented every month a list of the more important articles appearing in the Engineering Press and of the leading papers read before the various engineering institutions. Full names, addresses, and published prices of the publications indexed are printed each half-year in the volume index.

Civil Engineering.

Progress of construction on the Cross River Dam. *Engineering Record, 5th January*, 1907.

Ore-Shipment Pier at Almeria, Spain. *Engineering, 25th January*, 1907.

Modern Floating Dry-Docks. By A. C. Cunningham. *Technology Quarterly, December*, 1906.

The Quebec Bridge. *Engineer, 18th January*, 1907.

Wash Drill Borings on the New York States Barge Canal. By Emile Low. *Engineering News, 17th January*, 1907.

Progress of the Quebec Bridge across the St. Lawrence River. *Engineering News, 17th January*, 1907.

The Panama Canal—The "Lock Canal" Type and the "Straits of Panama" Type. By M. Philippe Bunau-Varilla. *Journal of Society of Arts, 25th January*, 1907.

Middlesbrough Docks. Completion of Reconstruction. By W. G. Kyle. *Iron and Coal Trades Review, 18th January*, 1907.

Panama. The Railroad and the Canal. *Railway Gazette, 1st February*, 1907.

Web Stresses in Plate Girders. By Prof. W. E. Lilly. *Engineering, 1st February*, 1907.

The Tehuantepec Railway and Terminal Ports. *Engineer, 1st February*, 1907.

Subway at Penarth Docks; Taff Vale Railway. *Railway Engineer, February*, 1907.

The Piney Creek Bridge, Washington, D.C. *Engineering Record, 26th January*, 1907.

Erection of the Main Vertical Posts of the Quebec Bridge. *Engineering Record, 26th January*, 1907.

The Las Vacas Viaduct on the Gautemala Railway. *Engineering Record*, 26th *January*, 1907.

The Teltow Canal. By Reginald Gordon. *Railway Gazette, 8th February*, 1907.

New Stone Bridge at Orleans. *Engineer, 8th February*, 1907.

The Walnut Lane Concrete Arch Bridge across the Wessahickon, Philadelphia. *Engineering News, 31st January*, 1907.

New Works at the Port of Brussels. *Le Génie Civil, 12th January*, 1907.

Building.

Forms for Concrete Construction. By Sanford E. Thompson. *Engineering News, 24th January*, 1907.

Practical Hints for Concrete Constructors. II. Some Points in Detail Design. *Engineering News, 24th January*, 1907.

The Conditions of the Steel Work in a San Francisco Building, erected 13 years ago. By Frank B. Gilbreth. *Engineering News, 31st January*, 1907.

Materials and Measurements.

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Track Construction in Paved Streets. By I. E. Matthews.

Concrete Stringer, Concrete Stringer with Ties, and Steel Ties. By F. D. Jackson.

Tie Plates, Braced Tie Plates and Tie Rods. By E. P. Roundey.

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Allis Chalmers Co., Milwaukie. Catalogue No. 131. Devoted to illustrated descriptions of machinery used in the treatment of gold and silver bearing ores.

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Consolidated Pneumatic Tool Co., Ltd., 9, Bridge Street, Westminster, S.W. Circular No. 17. Descriptive of the Rich chuck and high-speed flat drill.

Alfred Herbert, Ltd., Coventry. Catalogue, Section H, 1906, 1st edition, of milling machines, both horizontal and vertical.

Nasmyth, Wilson & Co., Ltd., Patricroft, Manchester. Catalogue of locomotives, representative of the various types constructed by this firm.

Geo. Richards & Co., Broadheath, Manchester. Catalogue of machine tools, pattern making machinery, air compressors, pulleys and line shaft fittings.

Albert E. Mallandain, 51, Cheapside, E.C. Edition B, catalogue of drawing office supplies. A comprehensive and useful list.

Simplex Conduits, Ltd. New list of screwed material, giving prices and particulars of conduits and fittings for a complete installation on the conduit system, using a screwed form of junction.

Brownlie & Murray, Ltd., Possil Iron Works, Glasgow. Catalogue of roof trusses, columns, bases, girders, and general structural steel work. The book is interesting in that it also contains much usual information and tables relating to structural steel work.

W. N. Brunton & Son, Musselburgh. Useful booklet giving directions for the various methods of splicing wire rope.

John Lang & Sons, Johnstone. New catalogue of lathes.

Jas. B. Petter & Sons, Ltd., Yeovil. Catalogue of the firm's patent oil engines. The booklet contains much information generally as is likely to be useful to users of mechanical power.

Seebohm & Dickstahl, Ltd. A booklet, entitled "Hints to Users of Tool Steel," that will be found acceptable and useful to all practically interested.

Dudbridge Iron Works, Ltd., Stroud. Catalogue of gas, oil, and spirit engines, and gas producing plant.

The Adjustable Cover and Boiler Block Co., Reading. Booklet of blocks and covers for steam boiler setting. These work to the expansion and contraction of the boiler, and offer certain advantages in facilitating examination.

Richard Hornsby & Sons, Ltd., Grantham. Booklet dealing with the Hornsby-Stockport gas engine and suction gas plant.

MANUFACTURERS' NOTES.

The Kennicott Water Softener Co., Great St. Helens, advise that they have sold to the Falls Flax Spinning Co., Belfast, a Type "A" water softener of 2,500 gallons capacity, and to the Luxembourg State Railways one of 6,500 gallons per hour capacity.

Messrs. H. Pels & Co. have recently secured orders for joist shears as exhibited at the 1906 Olympia Exhibition from the British Admiralty and the Japanese authorities; also for angle and T. bevel croppers from the Bristol, Gloucester, and Birmingham Wagon and Carriage Cos. Notching machines have recently been supplied to the Great Western Railway, American Car and Foundry Co., S. J. Clay, Ltd., Vickers, Son & Maxim, and others.

Kramos, Ltd., Bath, have opened their head sales office and showrooms for the "Kramos" special electrical tool equipment at 47, Victoria Street, Westminster.

The Haste Pump Co., Ltd., Openshaw, Manchester, have received the contract from the War Office for a water purifier to deal with 80,000 lbs. of boiler feed water per hour for Woolwich Arsenal, two orders for an automatic self-flushing filter from Messrs. Davis-Perrett for the Westminster Electric Supply Corporation, Ltd., and one of 10,000 gallons per hour capacity for the Sheffield tramways.

Translations. Most manufacturers have, at one time or another, been confronted with the difficulty of obtaining accurate translations of specifications, contracts, tenders, and similar documents involving technical terms, into a foreign language. We have recently had an opportunity of judging the quality of work of this kind undertaken by T. Demant, of 156, Northumberland Street, Newcastle-on-Tyne, in connection with, amongst others, the following industries:—Shipbuilding and marine engineering, electrical, hydraulic, mining and locomotive engineering, machine tool manufacture, and chemical trades, as a result of which we have much pleasure in making known the name of Mr. Demant to our readers.

PRIZE COMPETITION FOR ENGINEERS.

WITH the object of encouraging readers of THE ENGINEERING REVIEW to communicate their ideas and experience on subjects of engineering interest, we have decided to give

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SUBJECTS.

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The right is reserved of publishing the prize article, and also any of the others sent in; but in the case of the latter, payment will be made for the same at our usual scale rates.

The Editor's decision in all matters connected with the competition shall be final, and binding on all the competitors.

All articles should be addressed to the Editor of THE ENGINEERING REVIEW, 104, High Holborn, London, W.C., and marked on the outside, "Competition," and the same must be received not later than May 1st.